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Armed Conflict and Urban Growth Patterns: The Cases of Goma, Democratic Republic of the Congo, and Gisenyi, Rwanda

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Die Feldforschung hat bestätigt: Der Kongo ist nicht die Uckermark.

Abstract

This dissertation combines satellite imagery analysis and field research to investigate the influence of armed conflict on urban spatial development in the eastern periphery of the Democratic Republic of Congo (DRC) and western Rwanda. This border region continues to be affected by inter- and intra-state conflict since the early 1990s. The primary study area is the city of Goma in Congo's North Kivu province. Additionally, a comparison is drawn to the adjacent city of Gisenyi in Rwanda's Western Province.

The literature on urban areas in Congo and throughout Sub-Saharan Africa often refers to large primary cities. Little is known about urban development of secondary cities in conflict zones, and spatially explicit studies are rare. By combining satellite imagery analysis with semi-structured interviews and observations from field visits, this dissertation provides two complementary perspectives. The second chapter uses a time series of high-resolution Landsat images to analyze Goma's expansion between 1986 and 2015, a timeframe that includes conflict in Rwanda (1990-1994), the Congo Wars (1996-2003), and their violent aftermath. It shows how stages of urban growth relate to waves of forced displacement. The third chapter relies on very high-resolution (VHR) images for a fine-scale mapping of urbanization patterns between 2005 and 2014, and attributes them to groups of key actors. The fourth chapter extends the analysis to Goma’s Rwandan twin-city Gisenyi. It compares how inter- and intra-state conflict, and recent stability in Rwanda affect urban development across a national border. The dissertation concludes by reflecting on the utility and limitations of this methodological combination for conflict regions, highlighting areas for further research.

Zusammenfassung

Soziale, politische und geografische Prozesse der Stadtentwicklung in Konflikt- und Grenzregionen werden in dieser Dissertation durch eine Kombination von Satellitenbildern und Feldforschung analysiert. Das Untersuchungsgebiet ist die Grenzregion zwischen der Demokratischen Republik Kongo (DRK) und Ruanda, die seit Anfang der 1990er Jahre von zwischen- und innerstaatlichen bewaffneten Konflikten betroffen ist. Im Fokus der Analyse liegt Goma, die Provinzhauptstadt von Nord-Kivu im Osten der DRK. Zusätzlich wird ein Vergleich mit Gomas Zwillingsstadt Gisenyi in Ruandas Westprovinz gezogen.

Die Literatur zu urbanen Räumen im Kongo und in gesamt Subsahara-Afrika bezieht sich häufig auf Primärstädte. Über die Entwicklung von Sekundärstädten in Konfliktzonen, für die es kaum räumlich explizite Studien gibt, ist wenig bekannt. Diese Arbeit bietet zwei sich ergänzende Perspektiven durch die Kombination von Satellitenbildanalyse mit semi-strukturierten Interviews und Beobachtungen aus mehreren Forschungsaufenthalten. Das zweite Kapitel verwendet eine Zeitreihe hochaufgelöster Landsat-Szenen, um die Expansion von Goma zwischen 1986 und 2015 zu analysieren. Dieser Zeitrahmen umfasst internen Konflikt in Ruanda (1990-1994), die Kongo-Kriege (1996-2003) und deren von Gewalt geprägte Folgezeit. Das dritte Kapitel basiert auf der Analyse sehr hochauflösender Satellitenbilder. Eine feinskalige Kartierung von Urbanisierungsmustern zwischen 2005 und 2014 wird mit verantwortlichen Akteursgruppen verbunden. Das vierte Kapitel erweitert die Analyse auf Gomas ruandische Nachbarstadt Gisenyi. Es untersucht und vergleicht, wie sich zwischen- und innerstaatliche Konflikte und die jüngste Phase von Stabilität in Ruanda auf die räumliche Stadtentwicklung über die nationale Grenze hinweg auswirken. Die Arbeit schließt mit einer kritischen Reflexion über Nutzen und Grenzen des angewendeten Methodenmix und zeigt mögliche Bereiche für weitere Forschung auf.

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Prelude

"These are tents, since they are smaller than the usual houses in this area of town. So what we are looking at is most likely an internally displaced persons' camp," said one of my colleagues, as we squinted at the satellite image on my computer screen. But my other colleagues, political scientists and geographers, were not convinced. None of us had ever been to that city or to any other part of Central Africa at that time. "It is clearly a parking lot," said a voice from the back of the room. Another one immediately chimed in: "These structures are way too small to be huts or cars. What we are looking at are graves."

The city of Goma sits on the Congo's eastern periphery and shares a border with Rwanda. Starting in the 1990s, both countries were, and still are, the backdrop for years of genocide and civil war. Therefore, a displaced persons' camp seemed plausible.

Curiously, these alleged tents, cars, graves, or huts appeared to be quite scattered in Goma, on the Congolese side of the border. The imagery thus indeed resembled the pattern of tents that appeared in one of the satellite images of a known site of an internally displaced persons' camp. However, only meters away, on the Rwandan side of the border, sits the city of Gisenyi, where the objects were neatly aligned like cars in a parking lot. But why would dozens of cars be parked right beside the border but far away from the next crossing point? It didn’t add up. And the information derived from the satellite images did not provide satisfactory background information, either.

It was two years later that I recalled this meeting, as I was crossing the border from Goma into Gisenyi. By that time, I had driven past the suspected displacement camp many times and had discovered that it was indeed Goma's central graveyard. But the "neatly aligned cars" on the Rwandan side remained a mystery, so I asked a friend to take me there. Rwandan soldiers stood guard along the site to prevent people from illegally crossing the border. As we entered the area, it became immediately clear: what we had mistaken for parked trucks were also rows of graves. This cemetery had been recently opened, as Gisenyi's main cemetery was now at full capacity, partly due to the 1994 Rwandan genocide. What struck

me most was the orderly alignment of the tombs, as opposed to the rather chaotic distribution in Goma, right across the border. I didn't realize it at the time, but this simple difference between geometrical order on one side of the border and organic forms on the other side would become a morose testament to the geographical characters of the respective cities – Goma's organic and haphazard growth versus Gisenyi's planned, orderly surface.

Our erroneous interpretations of those satellite images years ago in my office would lead me to places (and people) whose untold stories are likely to fade silently into the past. This thesis portrays some of them.

Figure I-1: Goma central cemetery on the left side of the border, and Gisenyi cemetery on the right side. The white dots are tombs (Map Data: Google - Digital Globe, 2018).

Chapter I:
Introduction

1 Introduction

The two great wars in the Democratic Republic of Congo (DRC) (1996-1997 and 1998-2003), which involved several foreign armies and rebel groups, caused a continental crisis and ravaged the entire country (Prunier, 2008). Fighting and destruction did not spare the capital Kinshasa and other important cities. Yet, after several peace treaties and the official withdrawal of foreign troops, armed conflict persisted primarily in the country's eastern rural periphery (Vlassenroot and Verweijen, 2017, Vogel and Stearns, 2018). The Rwandan civil war, culminating and ending in a genocide (1990-1994), destroyed the country's capital Kigali, but counterinsurgency attempts during the conflict's aftermath were mostly based in the country's rural northwest. The cities at the center of these rebellions, Goma in eastern DRC and Gisenyi in Western Rwanda, were severely affected during the hot conflict phases (Prunier, 2008, Prunier, 1997, Stearns, 2011). Nevertheless, since the retreat of armed activities to the border-region, at the center of which both Goma and Gisenyi are located, these cities have experienced a relative stable growth, with an emphasis on the Congolese side (Büscher, 2011, Lamarque, 2014).

Studies of civil war in the DRC, Rwanda and throughout the African continent investigate the complexity of conflict causes and conflict repercussions. However, as many post-independence conflicts do not primarily occur within urban centers, and large shares of territory controlled by armed actors are peripheral, research on conflict causes, layers and effects often focuses on rural millieus (Büscher, 2011, Beall and Goodfellow, 2014). Whether cities in conflict areas turn into places of relative security or instability, depends on the political and institutional environment and on the conflict constellation, which can vary over time. This partly explains why the "[...] position and role of urban areas in the myriad forms of conflict affecting the continent are still little understood" (Beall and Goodfellow, 2014). Cities located in conflict areas constitute a particular case: they experience conflict-induced urban change either in the form of accelerated growth or extensive desertion, depending on their location within the conflict constellation.

Such spatial urban phenomena are a focal point in urban planning research and geographic information science. Research based on aerial photography, for example, compares slum morphologies in different African cities (Ilberg, 2009), and satellite imagery of the megacities is used to analyze urban-growth induced degradation of the non-built environment (Griffiths et al., 2010a, Moghadam and Helbich, 2013). But even if these data

are suitable for the analysis of the spatial development of cities in non-conflict and conflict areas, in academic research such studies are generally conducted within peaceful environments and, consequently, the effects of armed conflict on urban land-use change remain elusive[1] (Wilson and Wilson, 2013). This is surprising, especially in the context of protracted armed conflict and sustained state decay, where reliable data on population, infrastructure, or even topography are difficult to retrieve on the ground, and the existing data are seldom up-to-date.

In such hard-to-access environments, international and aid organizations such as the United Nations (UN) Office for the Coordination of Humanitarian Affairs (OCHA), UN Habitat, or Médecins Sans Frontières (MSF) have found remotely sensed data and geoinformation systems (GIS) to be reliable sources of information and tools for their analysis (Anthony, 2014, UNOSAT - UNITAR, 2014, Habitat, 2014)[2]. Population estimates can be generated by using satellite imagery to count the number of tents in displacement camps, to track population movements by monitoring the appearance and disappearance of such tents, and to delineate ground plots in villages newly inhabited by returnees, to avoid conflicts over land tenure (an employee of UN Habitat Kinshasa, 2016b, an employee of UN Habitat, 2016, an Employee of Esri Rwanda, 2017). Furthermore, geodata scientists do conduct analyzes on conflict environments, for example the expansion of displacement camps, or the monitoring of environmental degradation due such conflict-induced settlement growth. Yet, this academic research often lacks the basic empirical research on the ground (Kranz et al., 2010, Kranz et al., 2015), and there is little collaboration between fields of research like urban and conflict studies on the one hand, and between these two fields and geodata science on the other. However, such collaboration would be crucial to develop a more holistic

[1] Globally, more areas of the world, at least, since the inception of satellite remote sensing, have been peaceful compared to war related zones. This paves the way for more research to be conducted in peaceful environments compared to conflict zones. Furthermore, most researchers specialized in remote sensing techniques tend to avoid conflict zones with high levels of insecurity, and fieldwork in such areas can be impossible or highly constrained. Yet, most of the remote sensing based analyzes require access to the study area in order to collect ground truthing information for image classification accuracy assessment, and sometimes for training image classifiers. Additionally, if one has to account for the drivers of land change in conflict environment, fieldwork is absolutely necessary WILSON, C. O. March 2019 2019. *RE: Remote Sensing and Field Work in Conflict Zones.* Type to PECH, L..

[2] https://unitar.org/unosat/maps

understanding of the trends, and the forces driving the observed changes (Lidow et al., 2011, Raleigh et al., 2010).

Consequentially, the central aim of this dissertation is to contribute to the understanding of why and how urban environments develop in conflict and post-conflict scenarios, by bridging the methodological gap between disciplines working predominantly with either geographical information or empirical field research. The (secondary[3]) cities of Goma in the eastern Democratic Republic of the Congo and Gisenyi in western Rwanda serve as case study cities. Drawing on evidence from the literature on urban centers in conflict areas, peripheral towns, and conflict dynamics in the Congolese-Rwandan border region, the dissertation primarily analyzes and interrogates the particularities of spatial (peripheral) urban development in an area of protracted armed conflict through geographical data analysis paired with empirical insights into people's perspectives on the reasons for these developments.

In the following sections, I will position this dissertation in the current scholarly milieus of urban development and conflict research in Sub-Saharan Africa and geographic information science. I will then outline the approach through which data are gathered and analyzed, and describe why Goma and Gisenyi are of particular interest for addressing the spatial urban effects of conflict. The methodology and an overview of the dissertation structure conclude this chapter.

2 State of the Art

War and conflict have been and still are central features of Sub-Saharan Africa, as almost every region has been severely affected by one or more armed conflicts in the fight for independence or post-independence, and the number of armed conflicts has increased sharply since the end of the Cold War (Copson, 2016). The association of Africa with war and crisis, combined with the perception of African cities as sites of "contemporary misery"(Hall and Pfeiffer, 2013), thus reinforces characterizations of African cities as "the

[3] By definition, these secondary cities range between 500,000 and 3 million inhabitants and are frequently located at the margins of their national territory DE BOECK, F., CASSIMAN, A. & VAN WOLPUTTE, S. 2009. Recentering the City: an anthropology of secondary cities in Africa..

epitome of urban hell" (Beall and Goodfellow, 2014) or "the unsafest places in the world" (Kaplan, 1994). Yet it is by no means clear that violence and conflicts in African states occur predominantly in cities (Beall and Goodfellow, 2014).

Contemporary urban research conducted by "widely cited stars of urban studies [...] seldom make[s] reference to Africa" (Myers, 2011). In textbooks, African cities are typically subsumed as cities in the ‘less developed world’ and usually covered in a chapter that is disproportionately small considering the number of African countries (54 UN recognized countries in 2018), their population, and land area (Knox and McCarthy, 2005, Kaplan et al., 2004, Pacione, 2013). Although the last two decades have seen a reemergence of research on urban Africa, in part due to the growing attention of development organizations on the challenges of rapid urbanization, some trends prevail. Studies that focus on African urbanization tend to scrutinize individual cases of primary cities, most often the (colonial) capital, exposing a surprising lack of focus on smaller cities, partly explained by the historical absence of significant secondary cities. Only since gaining independence have most Sub-Saharan African countries urbanized, and only since the 1990s has population growth significantly accelerated in cities farther down the urban hierarchy (Pieterse, 2011, Myers, 2011). Therefore, secondary cities might be unknown outside their national or regional context, but are often leading cities within a (trans)national or global network (De Boeck et al., 2009, Myers, 2011).

On the one hand, African urban centers have been analyzed with a focus on political, economic, social, and environmental issues and crises, and on the challenges of rapid urbanization. In this literature, ‘the African city’ discursively represents (state) failure and reflects the erosion of state capacity, the decay of infrastructure, and the collapse of traditional social networks. Consequently, 'the African city' has become synonymous with the poor quality of life of its average urban resident (Myers, 2011, Cheeseman, 2015). On the other hand, research and literature on African cities focuses on functionalities that exist in spite of, or due to, political and socioeconomic difficulties. This research focuses on the creativity and resilience of urban dwellers in Sub-Saharan Africa in coping with the challenges that emerge from a malfunctioning public sector, a lack of economic prosperity, and an absence of social cohesion due to disturbances originating in colonial times (Trefon, 2004, Trefon and Kabuyaya, 2016, De Boeck and Plissart, 2014, Lall et al., 2017, Simone, 2006, Robinson, 2006).

The last two decades of heightened interest in urban Africa unveiled contradictory trends to the popular impression of (mega)city explosions (Myers, 2011, Murray and Myers, 2007, Simone, 2001, Pieterse, 2011). Studies combining census and satellite data show that continuously high urbanization rates might level off in countries such as Nigeria, Zambia, and Zimbabwe, as economic stagnation draws people from the cities back to the rural peripheries (Potts, 2012, Potts, 2009). In other countries, such as Angola, megacities have recently experienced a boom based on resource export revenues. Modernization projects, often financed by these revenues or an intense supply of foreign aid, rely on master plans inspired by the models of Dubai, Shanghai, or Singapore, which promise to turn cities like Kigali or Luanda into gateways for international investors. But, as the ensuing modernization measures include the destruction of poor neighborhoods and insufficient compensation for the evicted inhabitants, the most likely outcome is that rising inequalities will lead to a destabilization of local political economies (Watson, 2014, Pätsch, 2018).

A particular subsection of recent studies on African cities scrutinizes urban topics in conflict and post-conflict scenarios. Popular research topics include violence-induced forced displacement as a driver of the transformation from villages to cities or of the emergence of entirely new cities. Studies of Sub-Saharan African cities in conflict areas investigate the interlinkage between state decline and protracted armed conflict, track displacement patterns, and scrutinize socio-economic urban transformations (Büscher, 2011, Verhoeve et al., 2004). Other studies outline how living conditions deteriorate and cities depopulate due to armed conflict (Omasombo, 2005), or show how tensions worsen through conflict-accelerated urban growth, which in turn can lead to (conflict-induced) real estate booms (Branch, 2013, Mathys and Büscher, 2018, Peyton, 2018a). Some studies of African cities in conflict demonstrate how urban inhabitants deal with insecurity on a daily basis (Oldenburg, 2010, Oldenburg, 2012); analyze how the influx of international aid agencies creates a 'humanitarian urbanism'; show how long-term, large-scale refugee camps turn into permanent settlements (Jansen, 2016, Büscher et al., 2018, Mathys and Büscher, 2018); and portray how migrants intentionally move to cities at the center of war, seeing the potential for economic opportunities (Newhouse, 2017, Büscher et al., 2018). Urban research in (post-)conflict settings also shows how the influx demobilized combattants aiming to gain a place in a demobilization and disarmament camp causes city growth (Hoffman, 2007), or how entirely new (informal) neighborhoods are built by ex-combatants moving (back) to urban centers (Hoffman, 2017).

Urban centers in conflict areas can serve as safe havens for the population seeking protection, concentration points of public administration and the military apparatus, symbols of state sovereignty and public authority, or are where the strings for rebellions are pulled (Büscher, 2018a). However, despite the growing set of research on (secondary) cities in conflict areas, the causes and repercussions of armed conflict and urban development are mostly addressed separately, and urban studies in protracted conflict scenarios often have limitations in measurability and the spatially explicit analysis of urban development (Büscher, 2016, Büscher et al., 2018, Beall and Goodfellow, 2014, Beall et al., 2013, Verhoeve et al., 2004). This is especially important as, for most (urban) areas in Sub-Saharan Africa, the provision of detailed data on, for example, demography, land-use and infrastructure, economy and livelihood, or public services, are inconsistent, outdated, or non-existent.

To compensate for this scarcity of data, existing research has often relied upon field research, with the goal of gaining detailed knowledge through surveys and interviews, participatory observation, focus groups, and site visits (Kapiszewski et al., 2015, Cramer et al., 2011). Another way to conduct research on conflict and non-conflict environments is spatial analysis based on remotely sensed data and its derivations (e.g., OpenStreetMap data), which covers large areas and, irrespective of access constraints, allows for repeated and spatially explicit analysis of the land surface (Wulder et al., 2012). For example, two satellite imagery-based studies that integrate the urban scale while investigating the intensity of land-use change during the civil war in Sierra Leone combine their results based on (Landsat) satellite imagery with extensive field research. Through this innovative mix of methods, they were not only able to elucidate conflict-driven land-use change but also to retrieve information from the ground on major drivers for land-use change during peace time, such as a growing demand for agricultural products, poverty as a cause of uncontrolled deforestation, weak regulations concerning the mining sector, and weak environmental regulations in general (Wilson, 2014, Wilson and Wilson, 2013). Through a similar approach, another study investigates the degree of violence exerted by different armed groups during Liberia's civil war. The study finds that differing intensities and patterns of land use change are related to different rebel organizations and the intensity of violence exerted by them (Lidow, 2010).

Further remote sensing-based research conducted on conflict-induced land-use change in Sub-Saharan Africa has focused on war-related mining activities or forest loss and regrowth in the Democratic Republic of the Congo (Butsic et al., 2015, Nackoney et al., 2014, Kranz et al., 2010, Luethje et al., 2014, Kranz et al., 2017), ecological causes and repercussions of conflict in South Sudan and Uganda (Brown, 2010, Gorsevski et al., 2013), and the

development of displacement camps in Sudan's Darfur region (Hagenlocher et al., 2012). These studies, however, did not integrate field research into their investigations, thus leaving opportunities to further contextualize such findings to subsequent scholarship.

For non-academic analyses in conflict contexts, the combination of information derived from remotely sensed imagery and information gathered in the field is used, for instance, in the Syrian war to investigate the unlawful use of cluster bombs (interview with a researcher of Human Rights Watch Switzerland (2015)) and to monitor the ceasefire in eastern Ukraine's conflict areas (interview with a monitor of the Special Monitoring Mission to Ukraine (2018)). However, in academic research it appears that combining spatial data and qualitative field research is rarely pursued: conflict zones are often difficult to access to remote sensing experts, while conflict experts are rarely trained in satellite data analysis.

Thus, even though scholars using each approach acknowledge its respective deficiencies, few studies have overcome them by combining methods. A methodological combination of spatial analysis and field research, often applied in peaceful environments, could contribute to a more holistic understanding of conflict dynamics and repercussions.

To sum up, while there are studies using remote sensing methods to study cities on a more general level, and detailed field studies in conflict research (in Africa), the following research lacks can be identified: first, an urban perspective will supplement a literature that mostly focuses on rural geographical settings of conflict in Sub-Saharan Africa. Second, this thesis contributes to the very recent literature on secondary, peripheral cities, and how they have developed and are currently developing. Third, it fills a remaining knowledge gap left by the scarcity of research on paired border cities in conflict zones. And finally, this thesis will provide a rare combination of remote sensing and field-research.

3 Research Aim and Questions

This dissertation aims to address these key gaps in current research on spatial development of (secondary) cities in conflict areas in Sub-Saharan Africa.

More specifically, the following research questions will be answered:

RQ 1: What are the effects of protracted armed conflict on urban development at a) the overall-urban and b) the intraurban levels?

RQ 2: How does conflict affect cross-border differences in urban growth patterns?

4 Study Area

To address the research aim and questions, this thesis investigates the nexus between different phases of armed interstate and intrastate conflict and spatial trajectories of urban development of the secondary city Goma, in the eastern DRC, and then extends the analysis to the adjacent city Gisenyi in western Rwanda. The DRC and Rwanda have both experienced intrastate war and war with each other, and open conflict in the DRC and hostilities between the two countries continue until today (Lamarque, 2014). Goma serves as an ideal case to analyze the dynamics of conflict-induced urban development, as its built surface has more than doubled since the late 1980s (Peyton, 2018a). Right across the border, Rwanda's largest secondary town Gisenyi has not shown the same growth and prosperity as Goma, despite the cities' geographical closeness (Lamarque, 2014). Goma and Gisenyi evolved socially and economically interdependent and share a history of violence (Büscher, 2011).


DEMOCRATIC REPUBLIC OF THE CONGO AND RWANDA
National capital
District capital
City, town
Major airport
International boundary
District boundary
Main road
Secondary road
Railroad
0 100 200 300 km
0 100 200 mi
CAMEROON
CENTRAL AFRICAN REPUBLIC
SOUTH SUDAN
UGANDA
RWANDA
BURUNDI
UNITED REPUBLIC OF TANZANIA
ZAMBIA
MALAWI
ANGOLA
ATLANTIC OCEAN
Bangui
Libreville
Brazzaville
Kinshasa
Pointe-Noire
Cabinda (ANGOLA)
Luanda
N'zeto
Lobito
Saurimo
Luena
Mbandaka
Bandundu
Kikwit
Bolobo
Inongo
Kutu
Boende
Lisala
Bumba
Gemena
Libenge
Bangassou
Gbadolite
Bondo
Buta
Aketi
Basankusu
Bolomba
Yangambi
Kisangani
Basoko
Banalia
Bafwasende
Isiro
Watsa
Mungbere
Faradje
Juba
Gulu
Ituri
Bunia
Beni
Butembo
Kasese
Kampala
Jinja
Lake Victoria
Goma
Gisenyi
Kigali
Bukavu
Uvira
Bujumbura
Kindu
Kisangani
Punia
Ubundu
Ekoli
Peneluta
Lubutu
Ikela
Lodja
Kole
Ilebo
Kenge
Bulungu
Mweka
Lusambo
Kananga
Tshikapa
Kabinda
Mbuji-Mayi
Mwene-Ditu
Kahemba
Kapanga
Kamina
Kabalo
Kongolo
Kasongo
Mamba
Lubao
Kalemie
Kibombo
Kilembwe
Makobola
Kigoma
Tabora
Mpala
Moba
Manono
Kabamba
Pweto
Moliro
Sumbawanga
Mbeya
Katanga Plateau
Dilolo
Kolwezi
Likasi
Lubumbashi
Kipushi
Solwezi
Kasenga
Sakania
Ndola
Lake Mweru
Lake Bangweulu
Lake Kivu
Lake Tanganyika
Lake Kyoga
Lake Albert
Lake Edward
Lake Malawi
Ubangi
Congo
Lopori
Lulonga
Oubangui
Mongala
Uele
Kibali
Aruwimi
Ruzizi
Rukwa
Luapula
Luvua
Lukuga
Zambeze
Kasai
Kwango
Kwilu
Lukenie
Sankuru
Tshuapa
Lomela
Lulaba
Lomami
Luvua
Ouesso
Impfondo
Imese
Liranga
Gemena
Businga
Zongo
Ouesso
Mbandaka
Bolobo
Inongo
Kutu
Bandundu
Kikwit
Kenge
Bulungu
Ilebo
Kole
Lodja
Boende
Ikela
Basankusu
Bolomba
Yangambi
Kisangani
Basoko
Banalia
Bafwasende
Isiro
Watsa
Mungbere
Faradje
Bondo
Buta
Aketi
Lisala
Bumba
Gbadolite
Bangassou
Libenge
Gemena
Impfondo
Imese
Ouesso
Liranga
Mbandaka
Bolobo
Inongo
Kutu
Bandundu
Kikwit
Kenge
Bulungu
Ilebo
Kole
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Bumba
Gbadolite
Bangassou
Libenge
Gemena
Businga
Zongo
Bangui
Libreville
Brazzaville
Kinshasa
Pointe-Noire
Cabinda (ANGOLA)
Boma
Matadi
Mbanza-Ngungu
N'zeto
Luanda
Lobito
Saurimo
Luena
Dilolo
Kolwezi
Likasi
Lubumbashi
Kipushi
Solwezi
Kasenga
Sakania
Ndola
Kapanga
Kamina
Kabalo
Kongolo
Kasongo
Mamba
Lubao
Kalemie
Kibombo
Kilembwe
Makobola
Kigoma
Tabora
Mpala
Moba
Manono
Kabamba
Pweto
Moliro
Sumbawanga
Mbeya
Katanga Plateau
Mwene-Ditu
Kahemba
Kananga
Tshikapa
Kabinda
Mbuji-Mayi
Lusambo
Mweka
Bena
Mamba
Kasongo
Lubao
Kongolo
Kalemie
Kibombo
Kilembwe
Makobola
Uvira
Bujumbura
Kindu
Punia
Ubundu
Ekoli
Peneluta
Lubutu
Goma
Gisenyi
Kigali
Bukavu
Butare
Kasese
Kampala
Jinja
Butembo
Beni
Bunia
Ituri
Gulu
Juba
Faradje
Isiro
Watsa
Mungbere
Aketi
Buta
Bumba
Lisala
Gemena
Libenge
Businga
Zongo
Bangui
Bangassou
Gbadolite
Bondo
Uele
Ubangi
Congo
Mongala
Lopori
Lulonga
Oubangui
Aruwimi
Ruzizi
Rukwa
Luapula
Luvua
Lukuga
Zambeze
Kasai
Kwango
Kwilu
Lukenie
Sankuru
Tshuapa
Lomela
Lulaba
Lomami
Luvua
Lake Victoria
Lake Kivu
Lake Tanganyika
Lake Kyoga
Lake Albert
Lake Edward
Lake Malawi
Lake Mweru
Lake Bangweulu
Katanga Plateau
Lac Mai-Ndombe
Rukwa
Kivu
Tanganyika
Malawi
Mweru
Bangweulu
Albert
Edward
Victoria
Kyoga

The border region in which the two cities are located, is one of the most densely populated areas in Sub-Sahara Africa. Competition for land access, partly rooted in historical migration, colonial land privatization, and forced population relocation, triggered the first armed disputes in Congo shortly after the country's independence from Belgium in 1960 (Bucyalimwe Mararo, 2013). From 1965 on, President Joseph-Désiré Mobutu institutionalized land distribution as a reward for political loyalty, and the resulting clientelistic relations aggravated existing land disputes, particularly in Congo's eastern Kivu provinces. These disputes translated into armed conflicts between ethnic communities during the late 1980s, and mixed with the repercussions of armed conflict and the genocide in neighboring Rwanda during the mid-1990s. With the victory of the Tutsi rebel army Rwandan Patriotic Front (RPF), most perpetrators of the genocide fled towards Congo amongst Hutu civilians (Vlassenroot, 2004). In 1996, the Rwandan Patriotic Army (RPA), the new army created in 1994 after the RPF took power, invaded Congo in pursuit of those perpetrators. In the same vein, Congo's president Mobutu was overthrown by an armed insurgency, led by the Congolese Laurent Désiré Kabila and backed by Rwanda and Uganda, which plunged the country into the First Congo War. After seizing Congo's capital Kinshasa, Kabila declared his presidency in May 1997, while quickly alienating his Rwandan and Ugandan allies, provoking the outbreak of the second war in 1998 (Prunier, 2008, Reyntjens, 2009). This war involved 13 African countries, which either sent troops or provided logistical, financial, or political support to one of the warring parties, and countless Congolese and foreign or foreign-backed rebel groups and militias. Also called 'Africa's World War,' the war destabilized most of Central Africa, and its consequences are still felt today. In 1999, the United Nations deployed a peacekeeping mission to the Democratic Republic of the Congo (MONUC, today MONUSCO), which became the largest mission in UN peacekeeping history. In 2001, President Laurent Désiré Kabila was killed by his bodyguard, and Kabila's son Joseph was installed as interim president (Deibert, 2013). A peace settlement in 2003 paved the way for presidential elections in 2006, which were supported and observed by the international community. Joseph Kabila became the first democratically elected president of the DRC, but hope that stability had finally come to the country was shattered as armed groups continued to proliferate (Autesserre, 2008).

The Kivu conflict began with the seizure of South Kivu's capital Bukavu in 2004 and officially ended with a peace deal in 2008. However, fighting continued and a rebel group named M23 briefly took control of North Kivu's capital Goma between November and December 2012 (Berwouts, 2017). The government in Kinshasa, however, has shown little

to no interest in ending peripheral wars that do not threaten its survival (Vogel and Stearns, 2018). More armed groups are currently operating in Congo than were during the great wars, as longer standing large-scale, foreign-supported rebellions and rural self-defense coalitions have mixed. A count held at the end of 2017 identified more than 120 groups in Congo's two Kivu provinces alone (Vogel and Stearns, 2018, Vlassenroot and Verweijen, 2017). Furthermore, the chronically underpaid Congolese army, which officially collaborates with the MONUSCO, poses a major security threat. The peacekeepers, on the other hand, are regularly accused of ineffectively protecting the Congolese population from violence, despite their 'protection of civilians' mandate (Autesserre, 2014). Roughly six million people have died as a result of the direct and indirect repercussions of armed conflict in the DRC and, as of December 2017, 4.5 million people were internally displaced and between 800,000 and one million Congolese were refugees in Sub-Saharan Africa (UNHCR, 2018). Displacement caused by these multiple conflicts, combined with voluntary migration, has led to increased urbanization, war economies, and the movement of goods, all of which have clearly impacted the urban landscape (Büscher, 2011).

In contrast, Rwanda, which borders Congo’s North Kivu province, is ninety times smaller than the Congo and today is comparably stable and economically prosperous, although the country’s conflict history is no less difficult than that of its neighbor to the west. Rwanda was devastated by a civil war that began in 1990 with an invasion of Tutsi exiles fighting under the banner of the RPF. The war culminated in the Rwandan genocide, which began in April 1994 and ended that July with the RPF’s victory over the genocidal forces (Prunier, 1997, Straus, 2012, Umutesi, 2004). In contrast to the DRC, the RPF-led government has pursued ambitious policies aimed at top-down reconstruction and development since 1994, promoting, for example, good governance, decentralization, and poverty reduction (Straus, 2012). It has undertaken a series of projects including transitional justice, comprehensive land tenure, agricultural reform, and the (forced) resettlement of entire villages (Newbury, 2011, Huggins, 2017, Straus, 2012). The RPF’s actions are not limited to the Rwandan territory: in neighboring Congo, they include (unofficial) economic involvement and exploitation, and also played a major role in the regime change in 1997 and in different conflict episodes (Berwouts, 2017, Straus and Waldorf, 2011, Prunier, 2008). Rwandan development actions concerning urban issues have concentrated primarily on the capital Kigali, to the neglect of the country's remaining cities. Furthermore, rural-urban migration was, and still is, tightly controlled, and includes the (forceful) rehousing of rural populations to newly founded villages located along major roads, while many hilltop villages were

simply erased. This so-called 'villagization' process served as a counter-insurgency and modernization measure (an employee of the One Stop Center of Rubavu District, 2017, Ansoms and Rostagno, 2012, Newbury, 2011).

Rwanda's (six) secondary cities only gained governmental/political attention in 2015, when an action plan was created to modernize them and, at the same time, render their development sustainable (Government of Rwanda and GGGI, 2015). Close governmental control and relative stability since the end of war and genocide have brought about relatively moderate and closely controlled urban development, including secondary and smaller cities of Rwanda, one of the world's fastest urbanizing countries (Ansoms and Rostagno, 2012, Goodfellow, 2014).

Despite the increased urbanization of Congo's eastern provinces since the onset of violence, research on cities in the country's eastern periphery is rare, and research on adjacent cities in neighboring Rwanda is even scarcer. Only within the last decade has scholarly interest been paid to the significant socio-economic development of some of these cities (Büscher, 2016, Büscher, 2018a, Lamarque, 2014, Soi and Nugent, 2017, Peyton, 2018a, Doevenspeck, 2011). During Belgian colonization and the subsequent Mobutu era, Goma was a tourist magnet, located on the shore of Lake Kivu and famous due to its vicinity to Virunga National Park, with its active volcanoes and mountain gorillas. Today this border region is excluded from a number of tourist guidebooks for Africa, and the foreign offices of various European countries and the United States have issued travel warnings for the region because of a volatile security situation due to ongoing armed conflict(s). Yet despite its difficult security situation, or precisely for this very reason, Goma is a rapidly growing peripheral secondary city. The city's development is shaped by the repercussions of armed conflict, but also by processes of autonomization from the country's capital Kinshasa, informalization of urban development and livelihood opportunities, and 'glocalization' (a process in which institutional arrangements, and economic activities and networks become simultaneously more localized, regionalized and international), brought about through Goma’s role as an important hub for local, regional and international trade and transport, partly due to the fact that it possesses an international airport (Büscher, 2011). Furthermore, Goma's internationalization hast also been reinforced through a large presence of international organizations: the UN Office for the Coordination of Humanitarian Affairs lists more than 270 humanitarian organizations with headquarters in Goma alone (for 2013) (Peyton, 2018a), and the field office of the peacekeeping mission MONUSCO has been expanded by

800 (civilian) employees in 2013, followed by the establishment of the mission's eastern headquarters in 2014 and the deployment of 3000 additional soldiers in Goma's vicinity (pre configuration: 697 civilians, 274 Force) (Secretary-General of the United Nations, 2014, an employee of MONUSCO, 2016).

Goma's Rwandan counterpart Gisenyi shares a number of similarities, such as a colonial history and a colonially designed city center. But despite their proximity, the two cities feature asymmetrical trajectories of development, not only in terms of size and inhabitants (Gisenyi is notably smaller in area and population than Goma), but also with respect to infrastructure and planning. Goma's lack of urban infrastructure and its vibrant social and economic life, paired with an impressive national and international military presence, is contrasted by Gisenyi's tranquility and neatly organized city surface. The cities' common and differing trajectories will form part of this dissertation's analysis.

5 Methodology

This dissertation unravels the effects of protracted armed conflict on urban development at different spatial scales. Following from a city-scale analysis of urban expansion, it subsequently analyzes the spatial development in detail, and concludes with a cross-border comparison of the spatial urban development of Goma and Gisenyi. The observation period starts in 1986 through satellite imagery and ends in 2017 with a concluding field visit. This period spans several armed conflicts in Congo as well as the Rwandan civil war and genocide.

This dissertation builds upon the following methods and steps:

1) Firstly, remote sensing was used for the first analytical step, which consists of the visual interpretation of imagery at two different spatial resolutions. The first compilation of images stems from the Landsat system, a multi-spectral optical earth observation satellite mission with data freely accessible since 2008. These data were chosen because they enable time-series analyses across large-areas at moderate levels of detail (15x15 to 90x90 m pixels) (Wulder et al., 2012, Campbell and Wynne, 2011, Lillesand et al., 2014). The second set of data consists of very high resolution (VHR) imagery of up to 40x40 cm, and is provided by different commercially operated sensors (Quickbird, WorldView, GeoEye). Data at this spatial resolution is used because it is suitable for smaller research areas and detailed analyses of e.g., intra-

urban land use, or artisanal mining (Hamedianfar and Shafri, 2015, Luethje et al., 2014, Mukashema et al., 2014, Campbell and Wynne, 2011). Remotely-sensed imagery is digitized based on visual interpretation, followed by quantitative analysis of the resulting vector data and final cartographic depiction. The imagery and the mapped analysis results constitute the initial data used to pre-select specific sites to visit and to conduct interviews.

2) Secondly, (five) research trips to the DRC (Kinshasa, Goma) and Rwanda (Kigali, Gisenyi) took place. These visits served to conduct interviews to identify and investigate specific sites and patterns of interest together with the interviewees, with the aim of generating in-depth case knowledge. Contacts were established in a snowball fashion, and intensive networking established personal and professional contacts and trust to obtain access for site visits. The company of a member of the Congolese or Rwandan Red Cross, a local researcher, or by staff of Goma's volcanological research center opened doors to displacement camps, orphanages, or military sites, and ensured basic orientation, and sometimes translation (e.g., Swahili-French). Although the security situation never inhibited research during this dissertation, the rather opaque Congolese border regime, however, required an involuntarily shortening of one stay in Goma. The expulsion from Congolese territory was compensated for by the invitation of (Congolese) interviewees to Rwanda. Rwandan people were less open to conversations in public, especially at their workplaces (in Rwanda). Therefore, meetings with these interviewees took place privately, or in Congo rather than in Rwanda. A total of 62 interviews were conducted in a semi-structured/open fashion. Interviews were then analyzed by going through the handwritten notes and marking any similar information provided by (two, or ideally more) different interviewees on specific sites or topics.
3) The trips to the respective capitals of the two countries furthermore enabled the collection of information through reports from local administration, research institutions, and international organizations, and of literature not available outside the respective country.

6 Structure of this Thesis

Following the introduction in **Chapter I**, which presented the context and scientific background of the three core chapters, the three core chapters advance the research questions in accordance with the objectives. Each core chapter is either published in (II, III) or submitted to (IV) international peer-reviewed journals as stand-alone articles.

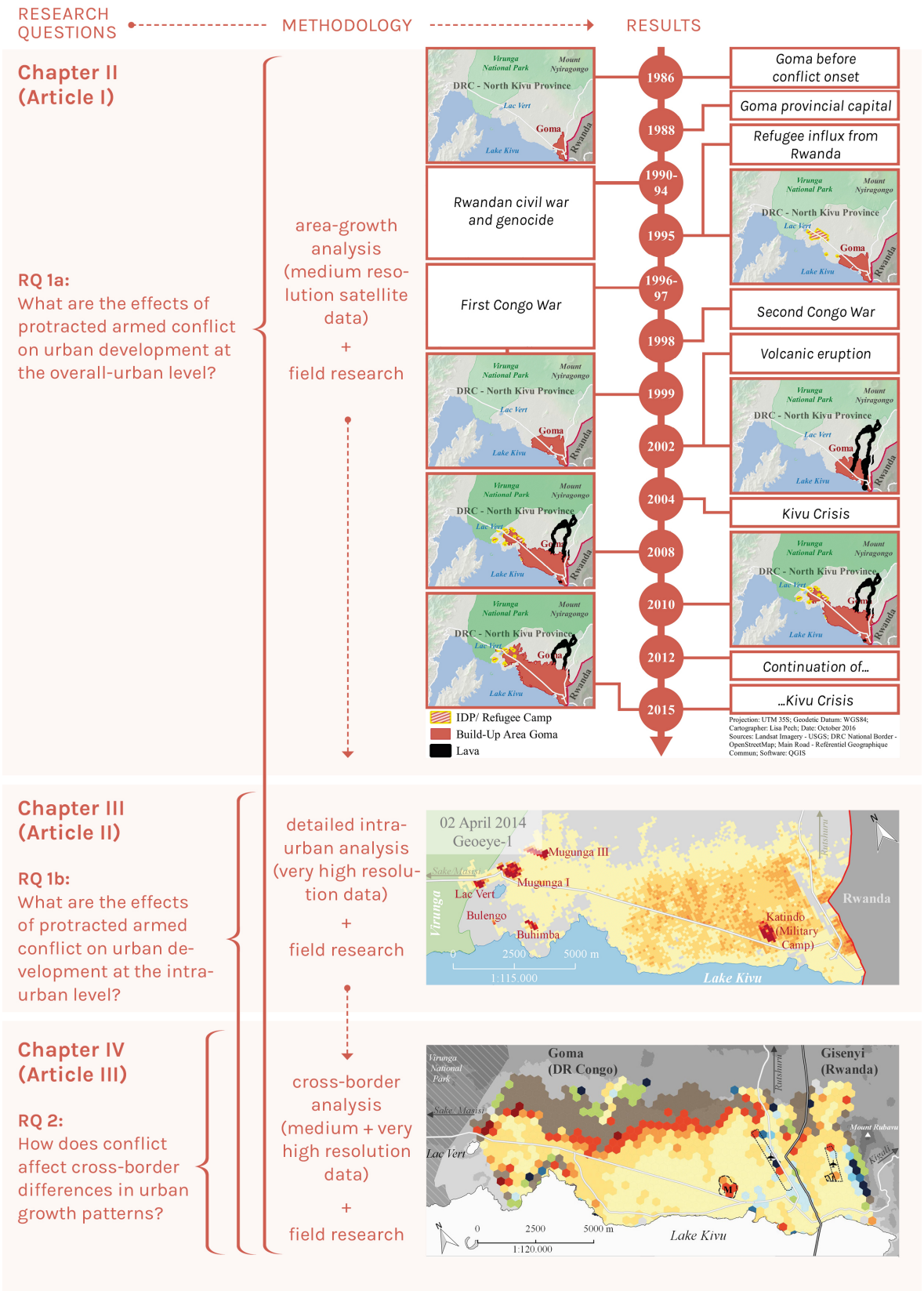

Figure I-2: Conceptual framework of core chapters. Chapter II: the methodological mix is established and (medium resolution) Landsat images are used to capture area growth. In Chapter III and IV, the analysis approach is expanded. Data of higher resolution are used to characterize urban development on a detailed level and to detect differences between the development of Goma and Gisenyi (IV).

Chapter II scrutinizes Goma's growth in area through almost three decades of armed conflict, focusing on waves of forced migration triggered by various violent events. This chapter puts particular emphasis on the combination of methodologies to underline the feasibility of satellite image application for non-experts in the remote sensing field:

Pech, L., Lakes, T. (2017). The impact of armed conflict and forced migration on urban expansion in Goma: Introduction to a simple method of satellite-imagery analysis as a complement to field research. Applied Geography,88, 161-173.

Chapter III looks at Goma's development through a spatially detailed lens, scrutinizing Goma's development at the individual neighborhood and building levels, during a shorter time period (10 years), to identify individual or groups of actors and drivers of urban development:

Pech, L., Büscher, K., Lakes, T. (2018). Intraurban development in a city under protracted armed conflict: Patterns and actors in Goma, DR Congo. Political Geography, 66, 98-112.

Chapter III crosses borders to compare the spatial development of Goma and Gisenyi in order to identify commonalities and differences in their urban development and the underlying drivers for these commonalities and/or differences: *Pech, L., Büscher, K., Levers, C., Walker, B. Armed conflict and cross-border asymmetries in urban development: a contextualized spatial analysis for Goma, Democratic Republic of the Congo and Gisenyi, Rwanda. (submitted, Land Use Policy)*

The dissertation closes with a synthesis (**Chapter V**) that summarizes and discusses the main findings of the three research papers as well as the limitations, regarding the central aim of shedding light on spatial development of (secondary) cities in conflict areas in Sub-Saharan Africa.

The dissertation ends with an outlook on future research directions and opportunities for further application of this methodology in conflict geographies.

Goma (2005)

Chapter II:

The Impact of Armed Conflict and Forced Migration on Urban Expansion in Goma: Introduction to a Simple Method of Satellite-Imagery Analysis as a Complement to Field Research

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Lisa Pech, Tobia Lakes

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Abstract

The effects of armed conflict on cities constitute a large field of research in both conflict studies and urban studies. The topic of urban expansion is also explored by the domain of remote sensing, a sub-branch of geoinformation science. Remote sensing analysts analyze the spatial development of cities in conflict and non-conflict environments using satellite imagery.

However, a dialogue or collaboration between these disciplines is virtually non-existent in the scientific discourse, mainly due to stark differences in their methodologies – namely, intensive, on-the-ground field research in the case of conflict and urban studies and highly elaborate computer-based analysis of remotely-gathered data in the case of remote sensing.

We aim to demonstrate a simple and thus feasible approach for use by non-experts of remote sensing to add a spatio-temporal dimension to the results of in-depth field studies. We apply our approach to the city of Goma, in the eastern region of the Democratic Republic of the Congo, which is located at the center of a protracted armed conflict that has raged for decades. With the support of local knowledge acquired during field visits, we visually analyze a time series of Landsat data and add our own results to those of existing research. Contextualizing the mapped results of Goma's urban expansion between 1986 and 2015, we show how urban growth is linked to particular waves of forced displacement caused by different stages of armed conflict and one particular natural disaster.

1 Introduction

Urban growth occurs rapidly in developing countries (López et al., 2001). The highest growth rates between 1995 and 2015 were observed in the least developed parts of the world, with Africa urbanizing most rapidly (UN Habitat, 2016). Urban expansion processes are often further accelerated by armed conflict near urban centers: In these environments, cities offer spaces of relative security and stability (Verhoeve et al., 2004) and thus act as a magnet for internally displaced persons (IDPs) (Branch, 2013). This effect leads to rapid growth, converting smaller urban centers into large cities (Beall et al., 2013, Beall, 2007, Lynch et al., 2013).

The relation between armed conflict and urban growth has been explored by the research of conflict studies, on the one hand, and urban studies and urban geography, on the other. Yet, when these two disciplines meet, a methodological void that is rarely addressed emerges.

Research from the area of conflict studies mainly focuses on violence *in* cities (Rodgers, 2016, Raleigh, 2015), to a large extent leaving out the effect of conflict *on* cities. The opposite is the case for the field of urban studies, which explores aspects of forced migration and rural-urban transformation (Branch, 2013) and its effects (Bartlett et al., 2012). Both fields address the topic of spatial processes; however, these fields only seldom utilize spatial data. This is explained by the fact that these disciplines, although scrutinizing the materiality of space, focus more on the social meaning of space (Chojnacki and Engels, 2013).

Spatial data in its *physical* denotation, on the other hand, form the basis for research in the field of so-called remote sensing, a sub-branch of geoinformation science. The remote sensing approach utilizes satellite imagery to derive measurable spatial (i.e., physical) data for analysis within a wide variety of research interests. In the context of armed conflict, recent studies utilize land-use change analysis, e.g., to understand the impact of warfare by measuring changes in crop area or forest cover during various stages of civil war (Butsic et al., 2015, Wilson and Wilson, 2013, Nackoney et al., 2014, Baumann et al., 2014, Lidow, 2010, Gorsevski et al., 2013). Others examine the sizes and environmental impacts of displacement camps (Giada et al., 2003, Kemper and Heinzel, 2014, Lang et al., 2010, Hagenlocher et al., 2012, Kranz et al., 2010, Kranz et al., 2015) or mining activities in conflict zones (Luethje et al., 2014, Kranz et al., 2017). Studies of the remote sensing discipline have also focused on the topic of urban growth or sprawl (Bhatta et al., 2010) in a non-conflict context (Griffiths et al., 2010b, Zhou et al., 2015) and, less often, in a (post-) conflict context (Wilson, 2014, Lynch et al., 2013).

Despite their different understandings of "space", remote sensing data can provide valuable insights to researchers from the fields of conflict or urban studies, as well: Satellite images (literally) supply a "view from above", which is especially beneficial for areas of limited accessibility. Unlike the indirect information of field research, which is often based on recounted evidence, satellite imagery delivers direct ("hard") data on the spatial aspects of development. Additionally, satellite imagery is available for long time periods of time and in consistent data formats, which guarantees reproducibility and inter-temporal comparability. In other words, in addition to the "view from above", satellite imagery can provide a "view into the past" necessary to understand the spatial dimension of conflict-related phenomena and to prepare for future events (e.g., humanitarian missions, mitigation of humanitarian crises, urban planning).

However, for the target group of urban and conflict researchers, elaborated remote sensing methods are too complex to be a feasible addition to the common methods of field research. This paper presents a reduced and thus simple and accessible way to interpret visual satellite imagery, which can be combined with classical field research. We demonstrate how this mixed-methods approach can enhance findings with a spatial dimension, i.e., linking observed phenomena to underlying processes and supporting image interpretation through local knowledge.

We demonstrate our approach by using a case study of the city of Goma in the eastern region of the Democratic Republic of the Congo (DRC) for the period between 1986 and 2015.

2 Data and Methodology

In this chapter, we introduce our region of study (the city of Goma) and our data sources, while also explaining basic terminology and providing key terms from the satellite imagery. Finally, we briefly comment on the software and analysis technique we applied.

2.1 Study Area: The City of Goma

Goma has received attention from various research communities, due to its peculiar features: As the capital of North Kivu province in the eastern region of the DRC, the city is located in an area under armed conflict since the early 1990s and is marked by rapid and dynamic growth. Goma is situated in the western branch of the East African Rift system, bordering Rwanda to the east and Lake Kivu to the south and situated only 14 km south of Mount Nyiragongo, one of the most active African volcanoes.

The illustration in **Figure I-1** shows Goma's area in 1986, before the outbreak of conflict over land in Masisi, a western territory of North Kivu, and before the outbreak of civil war in Rwanda in 1990 contrasted with its area in 2015.

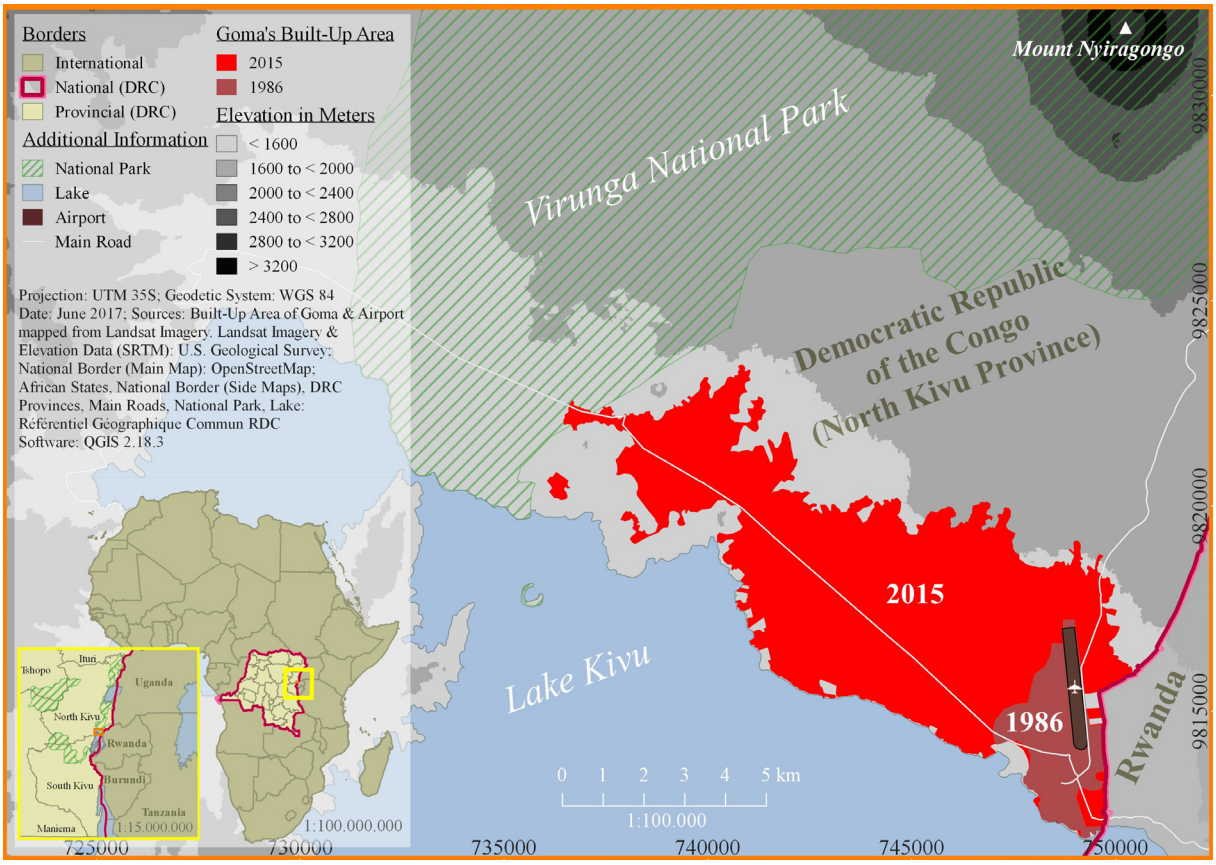

Figure II-1: Goma's area before (1986) the outbreak of armed conflict contrasted with its area in 2015

The recent history of Goma has been dominated by various armed conflict since the early 1990s. The security situation in the eastern DRC has been and continues to be controlled by changing constellations of non-state armed groups, the Congolese army (FARDC), national police, and the UN peacekeeping force MONUSCO (Mission de l'Organisation des Nations Unies pour la Stabilisation en République Démocratique du Congo). In addition to armed conflict, the eruption of the Nyiragongo volcano in January 2002 has had a dramatic impact on Goma's development. Lava flows destroyed nearly 40% of the city, and more than 14,800 families became homeless (Kanene, 2014). Linked to the volcanic activity, a high concentration of methane and carbon monoxide close to Lake Kivu's shore has rendered the city's position additionally hazardous. Despite these difficult conditions, Goma has experienced significant growth over the past few decades.

The impact of protracted conflict on Goma has been investigated from various disciplinary angles. In most cases, information collection has been based on extensive fieldwork. For

instance, two studies by Büscher (2011) and Oldenburg (2012) analyze the effect of violent conflict on social, political, and economic processes in Goma. A previous study by Büscher and Vlassenroot (2010) investigates the socioeconomic impact of the humanitarian industry and reveals how the presence of high-salaried international employees accelerates gentrification processes. Verhoeve et al. (2004) describe Goma as a place of relative security, encouraging the arrival of internally displaced persons. Informal cross-border economies between Congo and Rwanda via Goma are scrutinized by Doevenspeck and Nene (2012), analyzing the effects of specific uncertainties on either side of the border. Further topics of investigation are, e.g., the epidemiological consequences of war and disaster for the city (Bompangue et al., 2009) and the ecological impact of the large number of (Rwandese) refugees to Goma and its outskirts (Biswas and Tortajada-Quiroz, 1996).

2.2 Data Sources

Satellite imagery can stem from commercial, public (civilian), or military programs. Our imagery is sourced from the civilian Landsat program, initially designed to acquire data on earth resources and offering the longest continuous global record of the earth's surface since 1972 (Lillesand et al., 2014, p. 404, US Geological Survey, 2017). The program was founded by the US Department of Agriculture, the US Department of the Interior, and the National Aeronautics and Space Administration (NASA) (US Geological Survey, 2017). After a change in data policy in 2008, all Landsat data held by the United States Geological Survey (USGS) became freely available (Wulder et al., 2012). The imagery used for this study was acquired by three different Landsat satellites: Landsat 5 (1986-1995), Landsat 7 (1999-2012), and Landsat 8 (2014-2015). From 1996 until 1998 and again for 2013, no cloud-free data were available; information for these periods is exclusively based on existing research, literature, and interviews. **Table II-1** provides an overview of the data used for this study.

Table II-1: Satellite Imagery and Additional Data

Data	Spatial Scale, Spectral Information	Date/Year	Producer/Provider	Processing	Output & Use
Imagery					
Landsat 5	Multispectral: 1-5 + 7	1986, 1995, 1999	All Landsat images downloaded from USGS' Earth Explorer	Layer stacking, subsetting, Landsat 7 images (from 2003 on): "Gap filling" of data holes	Multispectral imagery for vectorization and mapping
Landsat 7	Multispectral: 1-5 + 7 + Pan[4] (Black/White)	2002, 2003 2006			
Landsat 8	1-7 + Pan	2008, 2010 2014, 2015		Visual interpretation & vectorization of respective city-extents	
VHR (WorldView 2) imagery	Multispectral	2015			Reference data and support for visual analysis
Google Earth VHR imagery	Multispectral	2003, 2006 2008, 2010 2015			
Maps					
Goma topographic map, 1982	1:7.500	1982	Defense Mapping Agency, USA		Urban Extent 1982 - before the start of armed conflicts
Goma topographic map, 2002/2003	1:10.000	2003	BCD Goma/Service de Cadastre de Goma	Georeferencing, projection, visual interpretation, and digitization	2003 + 2012 visual interpretation support => extent of urban area/ neighborhood boundaries
Goma topographic map, 2012[5]	1:11.000	2012	GIS unit MONUSCO		2003 + 2012
Goma's 18 neighborhoods, 2016		2016	Croix Rouge Congolaise		Orientation-aid during interviews
Additional data					
Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM)	30m resolution Terrain/Elevation	2000 2015			Terrain/Elevation depiction (final map products)
Shapefile: National Park, Lake, national boundaries	Boundaries/ Infrastructure				Boundary/Infrastructure mapping

[4] The panchromatic images of a higher resolution (15m) were used for validation purposes.
[5] Topographic maps were used for approximation and validation of urban extents at the time and for organizing site visits in Goma.

2.3 Key Terms and Data Formats of Satellite Imagery

Landsat sensors have a moderate spatial resolution, which varies between 15 m and 60 m per pixel, depending on the satellite-sensor generation and the spectral band. This allows for the detection of large man-made objects, such as urban and other large built-up areas of industrial zones and highways. The spatial resolution is coarse enough for global coverage, yet detailed enough to characterize human-scale processes such as urban growth (US Geological Survey, 2017). With a resolution of 30m, multispectral imagery meets our goal for identifying the spatial distribution of urban land cover and extracting historical urban growth areas. All imagery is delivered with radiometrical correction to reduce the effect of atmospheric interference (Lillesand et al., 2014, pp. 499, Campbell, 2008, p.297, pp.302). This normalization is beneficial for our study, as we compared surface reflectance of objects over time by using imagery of different Landsat sensors (Lillesand et al., 2014, p.502). Furthermore, the available Landsat data are orthorectified for distortions caused by relief variations and the tilt of the satellite sensor (Lillesand et al., 2014, pp. 171).

Images were delivered in separate spectral bands as *GeoTIFF* files, a standard image-file format for Geoinformation System (GIS) applications that allows for georeferencing information and includes an XML-file with metadata. The individual bands range from thermal, mid infrared, and near infrared (all of which are invisible to the human eye but important for the analysis of different surfaces) to the visible spectral range, comprising the blue, green, and red band (Lillesand et al., 2014, pp. 422). Depending on the satellite sensor, the number of bands varies. All bands can be displayed in different combinations, depending on the spectral characteristics of the feature under scrutiny.

2.4 Image Processing and Visual Interpretation Supported by Field Visits and Final Map Production

For further image processing, various software solutions are available, both open-source and those requiring commercial licenses. As a first step, we used *Erdas Imagine 2015*[6] to stack individual wavelength layers to one dataset per year, followed by the application of the focal analysis tool to fill data holes in the imagery from 2006 caused by a failure of the scan line

[6] *Erdas* is a commercial solution; open-source alternatives are e.g., *GRASS GIS* or the *EnMap Box.*

corrector of Landsat 7 (Scaramuzza and Barsi, 2005, p.1). All images were subsetted to the Goma region.

The resulting images can then be used for visual interpretation. For our research, the image content needed to be divided into built-up and non-built up areas. This step is commonly accomplished by (semi-)automatic algorithms. However, as such processing requires in-depth knowledge and as the aim of this survey is the accessibility for researchers outside the field of remote sensing, we conducted this step manually based on visual interpretation,[7] information from field visits, and local interviews.

For this visual interpretation, we depicted each dataset in three different band combinations in the open-source software *QGIS*. To delineate urban from non-urban land use, we applied a natural color and two infrared combinations to delineate vegetation and built-up area.[8] These were superimposed and compared visually. Due to the retrospective nature of our study, it was necessary to employ a variety of reference data and supporting materials such as Google Earth historical imagery, (topographic) maps, georeferenced photos from field visits, and interviews with people familiar with Goma, as well as image consultation with these interviewees.

A total of 17 interviews and site visits were conducted for this study. Of these interviews, four took place in Kinshasa (January and July 2016), six in Goma (February/March and August/September 2016), six in Gisenyi, Rwanda (February/March 2016), one in Bonn, Germany, and one in Berlin, Germany.

The interviewees were divided into two groups of experts: first, members of UN agencies, NGOs, national administration, and provincial administration. This group was consulted for general information on issues linked to Goma's development, such as the armed conflicts in the region, displaced persons, and humanitarian aid. The second group was comprised of interviewees and field visit partners with a long history or ongoing residency in Goma (10-30 years), specifically at the time the satellite image in question was captured. Due to a lack

[7] Automated methods can also turn out to be infeasible – which was the case in our study: Test-runs of unsupervised and supervised (Maximum Likelihood) classifications for the 2015 Landsat imagery showed a high confusion between urban/built-up area and open soil when comparing the results with commercial very-high resolution (VHR) imagery (*WorldView 2*) from 2015.

[8] Natural color: 3, 2, 1 for Landsat 5 and 7, 4, 3, 2 for Landsat 8; vegetation: 4, 3, 2 for Landsat 5 and 7, 5, 4, 3 for Landsat 8; 5, 4, 3 for Landsat 5 and 7, 6, 5 ,4 for Landsat 8.

of other quantifiable criteria, a long residency was considered to be a good approximation for ensuring local knowledge.[9]

The satellite imagery, accompanied by a topographic map, was taken along to receive expert knowledge on the identified structures and the respective city limits. A mental map of Goma's neighborhoods (acquired at the local Red Cross office, drawn by a volunteer) served to structure the interviews for those interviewees who had difficulties relating to the imagery or to the topographic map. The interviews were complemented by visits to specific parts of the city that seemed particularly relevant to urban expansion processes, as well as to areas pointed out by the interviewees.

As the next step, the results of the interviews were used to delineate the extent of built-up area on the individual satellite images. These borders were then vectorized using the editing function in *QGIS*.

We thus received ten layers (shapefiles) with the respective spatial extents of Goma. Higher-resolution data (panchromatic images of Landsat 7 and 8, commercial data provided by Digital Globe, Google Earth historical imagery) and the validation of mapped results with interviewees allowed for consistency across time to be verified.

The final map design was performed with *QGIS*, combining the vectorized city extents with additional data such as the satellite imagery, a digital elevation model (DEM) from the Shuttle Radar Topography Mission (SRTM), and shapefiles of the national boundaries, Lake Kivu and Virunga National Park.

A scheme of this map production procedure, as described above, is provided in **Figure II-2**.

[9] Exemplary questions: "How big is the impact on forced displacement in cities in the eastern DRC? Can you give an example/ numbers?", "What site/landmark can you identify on this image as an important landmark – the city boundary at that time?"

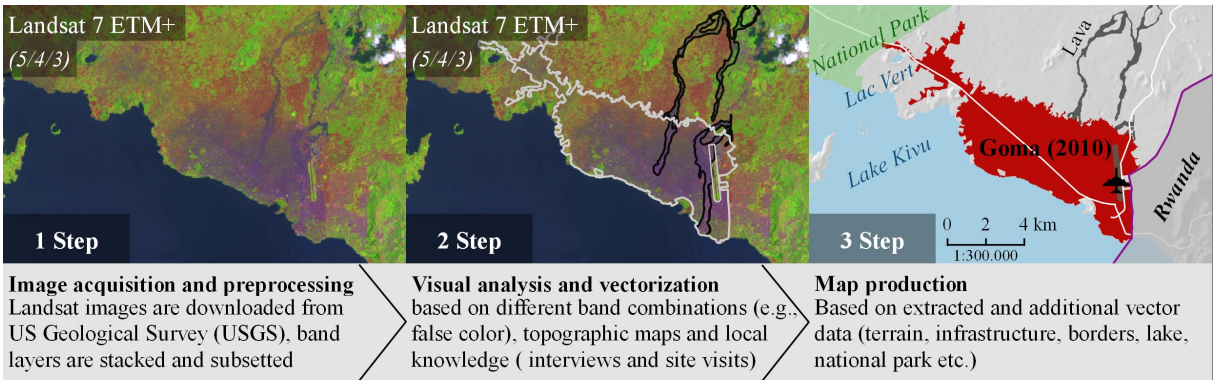

Figure II-2: Processing steps

3 Results: Mapping Spatial Repercussions of Forced Displacement

This chapter presents our satellite-imagery maps and puts them in chronological context with phenomena related to the protracted conflict situation, as discussed in the literature, press, and humanitarian reports. In line with our mixed-methods objective, we complement the mapped results with information we received during field visits and interviews.

3.1 Internal Displacement, Rwandan Refugee Camps, and the First Congo War

Between 1990 and 1996, Goma experienced the impact of internal population displacement and a wave of refugees from Rwanda (Büscher and Vlassenroot, 2010). In 1993, land conflicts along ethnic lines in the Masisi and Walikale territories west of Goma "displaced considerable numbers of rural inhabitants (towards the city)" (Büscher and Vlassenroot, 2010, p. 259). At the same time, civil wars took place in neighboring Burundi and Rwanda. The latter culminated in the Rwandan genocide, ending in July 1994 with the victorious Tutsi-led *Rwandan Patriotic Front* (RPF) taking over government functions (Prunier, 1997, p. 299). This regime change caused a mass exodus of Rwandan Hutu towards the DRC, then called Zaire (Prunier, 2008). Between July and August 1994, around 850,000 Rwandans fled to Goma and its surroundings. Among these refugees were about 40,000 members of the former Armed Forces of Rwanda (FAR) and the former Hutu regime (Prunier, 2008, p.25).

The extent of Goma's built-up area increased from 7 km² in 1986 (**Figure II-4, upper slide**) to 21.3 km² in 1995 (**Figure II-4, middle**), including 4.8 km² of refugee campsites, identified by several interviewees on the imagery (an employee of UN Habitat Goma, 2016, an employee of UNHCR Goma, 2016, an employee and a volunteer of the Congolese Red Cross, 2016, a researcher of Pole Institute Goma, 2016b, a researcher of Pole Institute Goma, 2016a). Previously, published information on the (exact) location of the smaller camps had

been rather anecdotal. The large camps visible on the images in the northwestern part of Goma are *Mugunga* and *Lac Vert*; the smaller ones form a campsite called *Buhimba*, which beginning in 2008 has hosted Congolese displaced persons intermittently (Pro Act, 2007, p.19, an employee and a volunteer of the Congolese Red Cross, 2016), the *Bananeraie* (banana grove) housing the former Rwandan military (Terry, 2013), and a site with an unknown name. According to an interviewee during a site-visit, remaining structures of the Buhimba refugee camp were still identifiable in August 2016 (an employee of UNHCR Goma, 2016, an employee of the Congolese Red Cross, 2016).

Figure II-3: (left)IDP Camp Mugunga 1 in August 2016 (author's image), constructed at the same location as the Rwandan refugee camp; (right) remains of a latrine at the Buhimba refugee camp (photo courtesy of Congolese Red Cross)

Mugunga camp gave shelter to approximately 125,000 to 200,000 people between 1994 and 1996 (Prunier, 2008, Biswas and Tortajada-Quiroz, 1996, an employee and a volunteer of the Congolese Red Cross, 2016) in an area of 2.5 km². Lac Vert housed an unreported but most likely similar number of inhabitants (an inhabitant of Mugunga, 2016, an inhabitant of Goma, 2016) on an area of 2 km². In Lac Vert camp, the satellite imagery allowed for the identification of infrastructural patterns such as paths and parcels. The three smaller campsites measured about 100 m², respectively. Due to the alarming humanitarian situation at this time, about 150 different international organizations arrived in Goma, from where their activities were coordinated and further dispatched (Büscher and Vlassenroot, 2010, p. 260). This humanitarian boom led to the further growth of Goma's population: first, due to the international employees themselves and second, due to Congolese attraction to the possibility of employment by one of these organizations or their employees. Furthermore, the situation presented new opportunities for local politico-economic elites (an inhabitant of Goma, 2016, an employee of Deutsche Welthungerhilfe, 2016, Büscher and Vlassenroot, 2010, p.260).

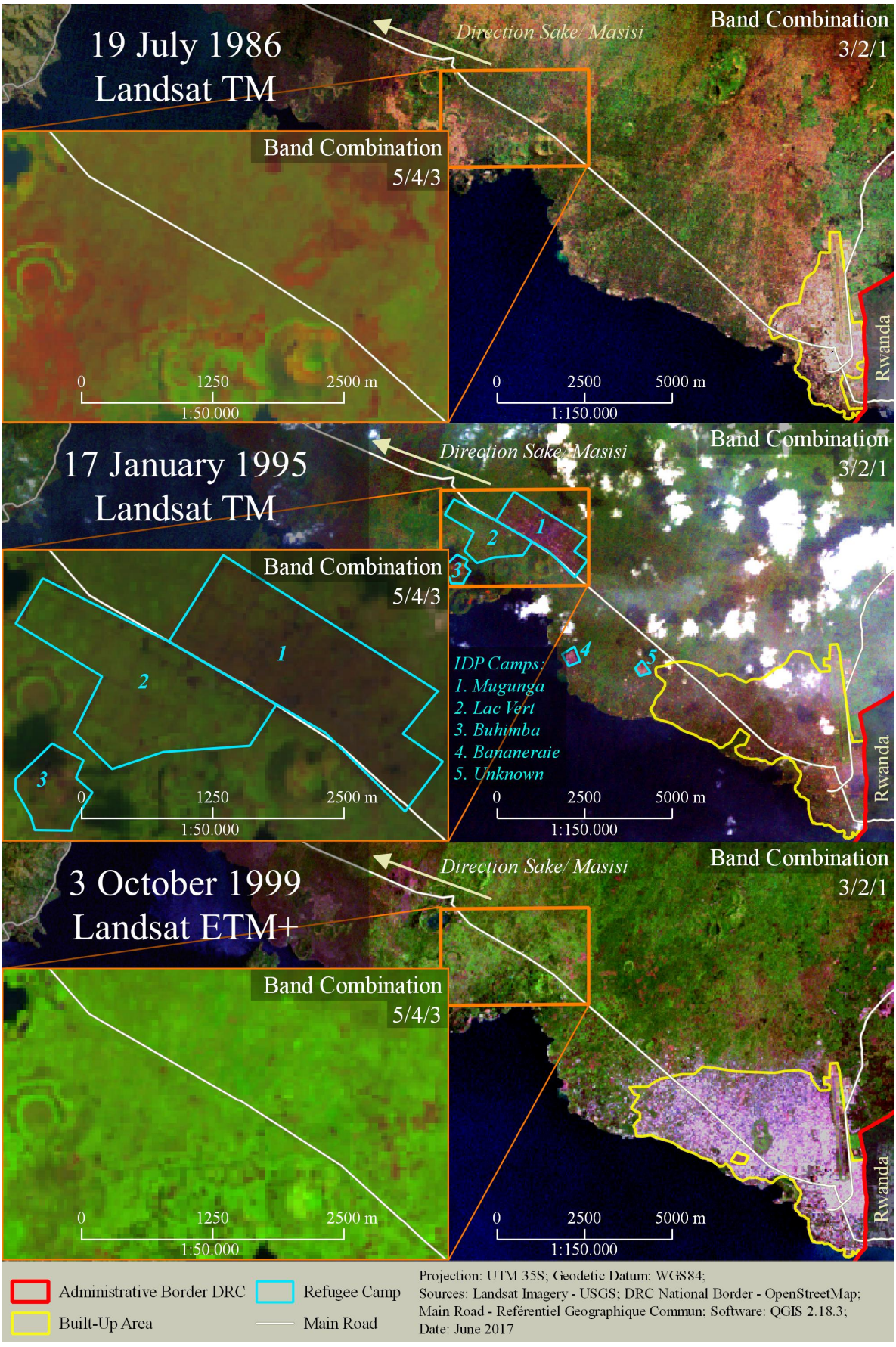

Figure II-4: Goma 1986, before conflict; 1995, built-up area expanded and several refugee camps have sprouted around the city; 1999, camps have disappeared and Goma's built-up area has expanded further

The presence of the partially militarized refugee camps was the main reason for the Rwandan leadership to invade the Congo in the autumn of 1996, constituting the beginning of the First Congo War (1996-97) (Prunier, 2008, pp. 67). The invasion took place in concert with a rebellion to overthrow president Mobutu, the Alliance of Democratic Forces for the Liberation of Congo (AFDL), fronted by Laurent-Désiré Kabila and supported by Rwanda, Uganda, and Tanzania (Deibert, 2013, p.55).

As other refugee camps in North and South Kivu came under attack first, the camps around Goma continued to grow (Johnson et al., 2016, p. 142, Umutesi, 2004, p.120), and by 8 November 1996, Mugunga was home to about 800,000 inhabitants (Prunier, 2008, p. 118). During this war, Goma shifted from a peripheral town to a leading military center. Additionally, thousands of internally displaced persons from Goma's neighboring territories of Masisi and Rutshuru arrived in Goma, searching for protection from attacks by rural militias (Büscher and Vlassenroot, 2010, pp.261).

On 13 November 1996, Mugunga and the other camps were hastily closed following Rwandese mortar and infantry attacks, dispersing up to one million refugees (Prunier, 2008, p. 120). According to contemporary witnesses,[10] within just a few days, no trace of the camps remained (an employee and a volunteer of the Congolese Red Cross, 2016, an employee of UN Habitat Goma, 2016, an inhabitant of Goma, 2016). Goma's urban (core) area had expanded from 16.5 km² in 1995 to 19.84 km² in 1999, but roughly 5 km² formerly covered by refugee camps had been re-converted into fallow land (**Figure II-4, lower third**).

3.2 Volcanic Eruption, Inner-City Displacement, and Expansion during the Second Congo War

While the first Congo War transitioned almost seamlessly into the second (1998-2003), Mount Nyiragongo erupted on 17 January 2002 and destroyed a third of Goma’s built-up area, leaving between 12,000 and 14,800 families homeless (Inglada et al., 2003, Kanene, 2014). The lava flows that affected the city center are clearly visible on the image from 2002 (**Figure II-5**).

[10] Due to unfavorable cloud conditions, the earliest available imagery dates to October 1999, and we thus strongly relied on information from the literature and from contemporary witnesses.

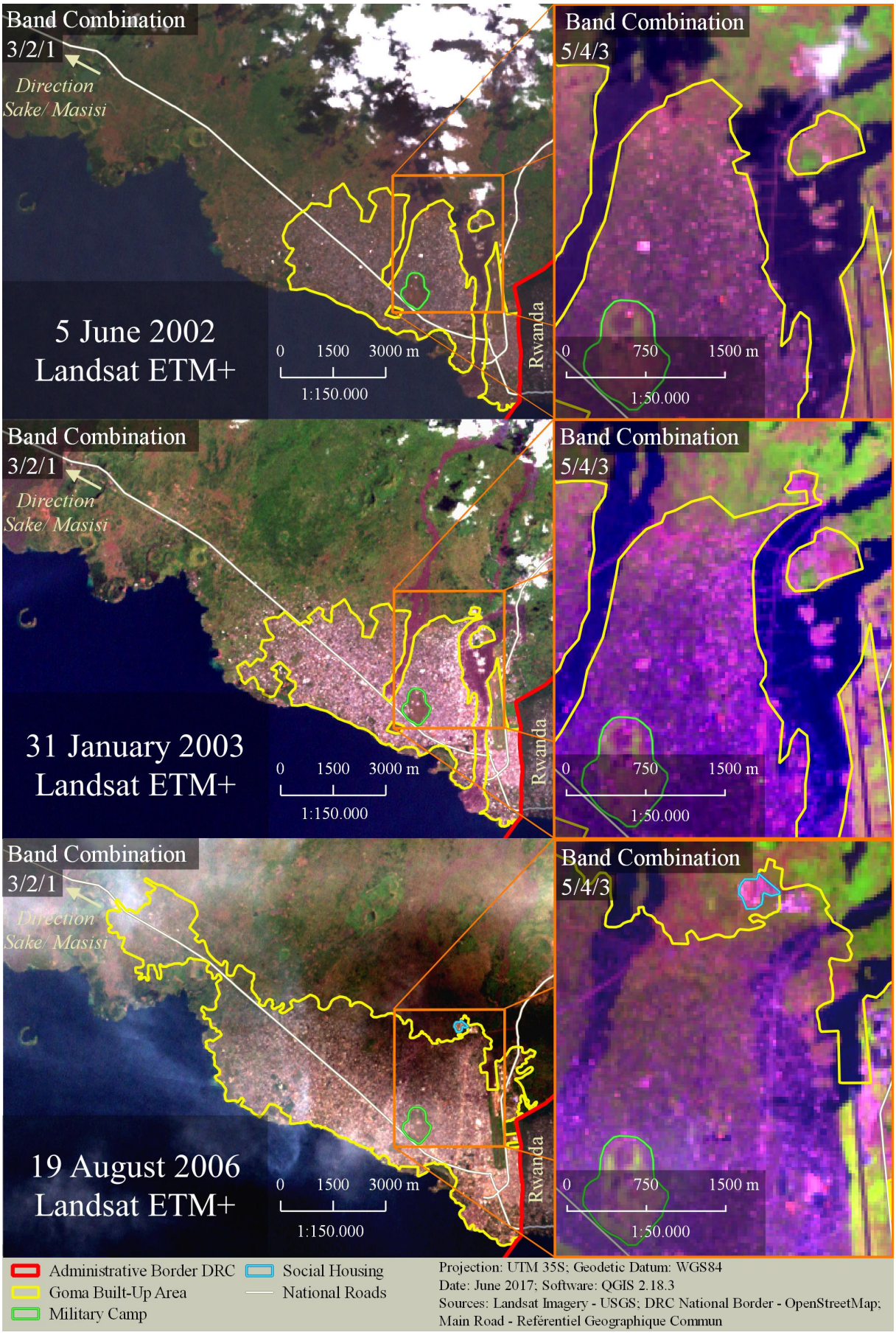

Figure II-5: 2002, the volcanic eruption destroyed a third of Goma's buildings; 2003, lava is partly covered by new buildings; 2006, density of built-up area has increased, Goma has expanded westwards

The Goma faction of the rebel movement Rally for Congolese Democracy (RCD Goma) – at that time, in charge of politico-military affairs in town – was helpless in the face of the major destruction, as was the central government (Oldenburg, 2012, p.99). Even though Goma did possess an urbanization and land registry service, their offices were disengaged from 1993 onwards because of the conflicts in the region (Verhoeve et al., 2004, p.108, an employee of the provincial ministry of urban planning, 2016a). This absence of any central planning left the urban population to its own devices during this emergency situation (Büscher, 2011, p.72, Verhoeve et al., 2004, p.109, 110). One consequence of the volcanic eruption was a mostly unplanned westward expansion of urban area and a densification of western neighborhoods untouched by the destruction (an employee of UN Habitat Kinshasa, 2016a, a homeowner and her family in Ndosho, 2016, a professor at ISAU Kinshasa, 2016, Verhoeve et al., 2004, pp.109). Subsequently, the government's inaction concerning communication, evacuation, or humanitarian aid measures led to an influx of aid workers comparable to that of the aftermath of the Rwandan civil war (an employee of UN Habitat Kinshasa, 2016a). Due to both the lack of buildable ground and a temporary drop in land prices in the areas affected by the volcanic eruption, lava sites were already partly covered with new buildings in the image from 2003, despite their hazardous location {an employee of UN Habitat Kinshasa, 2016 #177;a masterstudent from Goma at ISAU, 2016 #290;an inhabitant of Goma, 2016 #302}. As the city expanded westwards, two still rather rural neighborhoods of Goma were incorporated into its urban area: Mugunga and Lac Vert, the former locations of the Rwandan refugee camps (an employee and a volunteer of the Congolese Red Cross, 2016).

3.3 Goma as a Magnet for Internal Displacement – the Kivu Conflict

Despite several peace accords, violence did not come to a halt in Congo's eastern provinces, causing multiple waves of displacement. More than two million internally displaced people are estimated to presently live in the eastern DRC, 900,000 of which reside in North Kivu (an employee of UN OCHA Kinshasa, 2016c).

What turned into the third Congo War, also referred to as the Kivu Conflict, got its start with tensions in February 2004, taking off in April with several clashes between Rwandese or Rwanda-backed rebels and the Congolese army, partly supported by UN troops (Prunier, 2008, pp. 296). This caused the displacement of several hundred thousand people within South and North Kivu in May 2004, including an exodus toward Rwanda and Burundi. In May 2004, the CNDP rebel movement (Congrès National pour la Défense du Peuple)

proceeded to Bukavu, the provincial capital of South Kivu (Prunier, 2008, p.298), causing the flight of tens of thousands towards the north, with many of the displaced staying in Goma (an employee and a volunteer of the Congolese Red Cross, 2016, an inhabitant of Goma, 2016). After the CNDP's withdrawal from Bukavu in June, fighting spread to the north (Prunier, 2008, p.298). In December 2006, clashes between the FARDC, backed by UN troops and the CNDP, which controlled the Masisi mountains west of Goma, again caused the displacement of tens of thousands (Johnson, 2014 #226), pp. 157. Beginning in the end of August 2007, many of the displaced settled in the city's western neighborhoods of Mugunga and Lac Vert along the main road (an employee and a volunteer of the Congolese Red Cross, 2016, an employee of UN Habitat, 2016, an employee of Deutsche Welthungerhilfe, 2016). The development of these camps, accompanying different peaks of violence, can be observed in the imagery, as displayed in **Figure II-6**. The first available cloud-free image dates to February 2008, showing the camps Mugunga 1 and 2, Buhimba and Bulengo (clockwise from the first northwestern camp). The camps are located in the same areas as the refugee camps between 1994 and 1996 (an employee of the Congolese Red Cross, 2016). Also visible in the imagery is the development of the military camp (Katindo) in the city center (encircled in green), successively filling up with huts. By the end of April 2008, there were between 750,000 and one million IDPs in the entire North Kivu province (Johnson, 2014, IDMC and NRC, 2010, p.4), with Goma expanding further westwards and measuring 40 km² with an additional 1.2 km² of IDP camps.

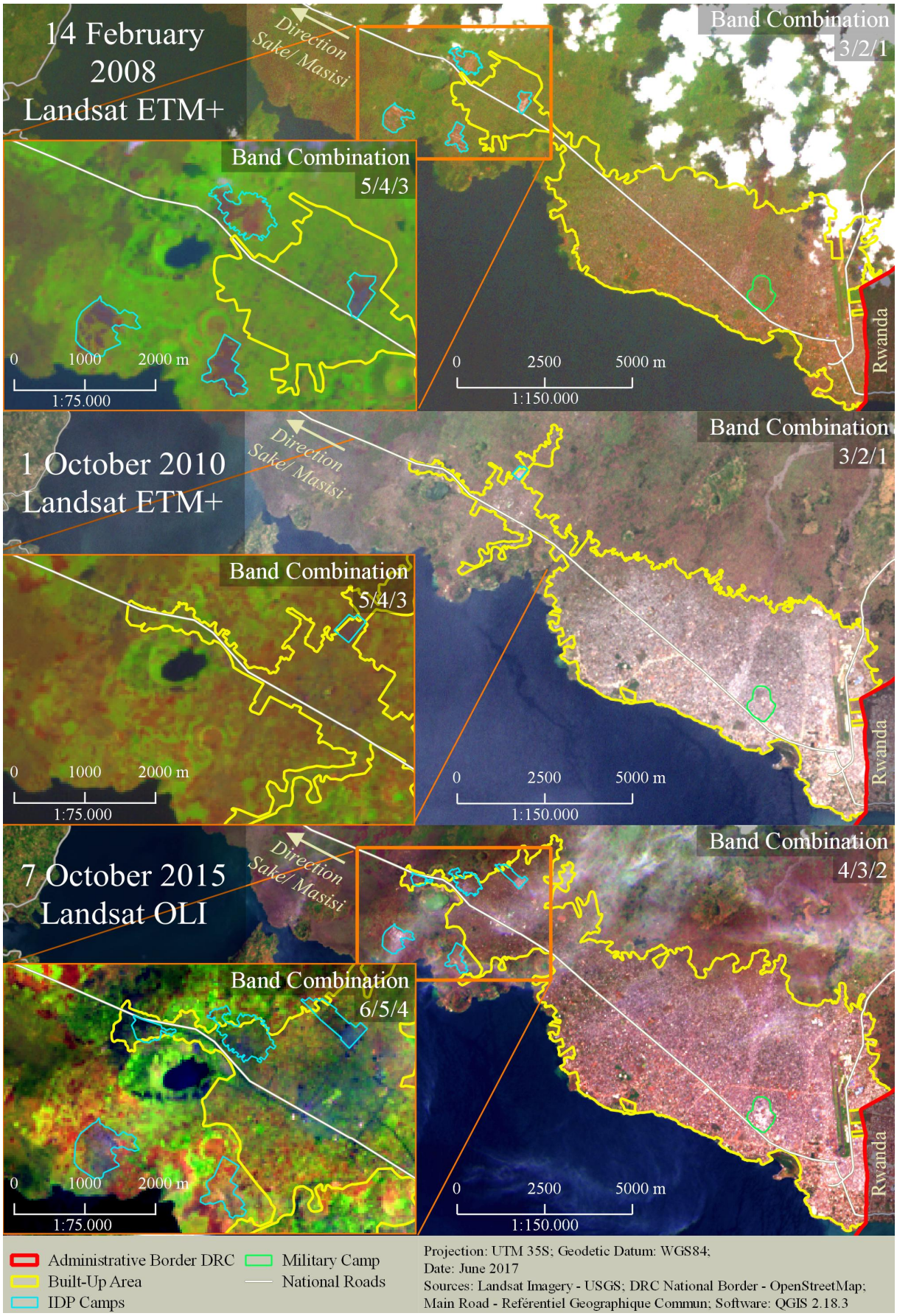

Figure II-6: (Dis)appearance of IDP camps in Goma's western outskirts after clashes between FARDC and rebel groups; Katindo military camp in the city center filled with huts with increasing military presence

Combat between the CNDP and the FARDC ended in January 2009. The CNDP combatants agreed to integrate into the Congolese armed forces and to support military operations in cooperation with the Rwandan army against another rebel organization, the FDLR (Forces Démocratiques de Libération du Rwanda). After Rwanda had withdrawn its troops, the FDLR committed revenge killings and mass rapes of Congolese civilians. Furthermore, the chaotic integration of CNDP rebels worsened the already precarious situation of the Congolese army, which contributed to the deterioration of the security situation and to an increase of abuses committed by army members. Displacement of civilians towards Goma continued (Johnson et al., 2016, pp. 298).

In the image from October 2010 (**Figure II-6**), Goma's built-up area covered 43.5 km² and had begun to incorporate IDP camp areas, which, with the exception of Mugunga 3, had been closed following UNHCR's announcement that the IDPs had decided to return home (Büscher, 2011, p.230). Built-up area within Katindo military camp further increased, due to increased military deployment and the reunion of family members. Additionally, the camp served as shelter for displaced persons who could not settle in camps, such as stigmatized young women and other displaced youth (an employee of UN Habitat, 2016, Liebling et al., 2012, p.22).

In 2011, an army reform led to a temporary void of military control across the country. An appeal to armed groups to demobilize voluntarily and integrate into the FARDC also failed. Entire regions fell under the control of different armed groups, causing further rural exodus. Additional insecurity was caused with the creation of the M23 in May 2012, the successor of the CNDP movement (Baaz and Verweijen, 2013, p.563). In July 2012, the M23 captured the territorial capital Rutshuru 60 km north of Goma. Despite more FARDC deployment to Goma and the presence of the UN peacekeeping force, the city was captured by M23 in late November 2012 (Deibert, 2013, p.200).

Due to the conflict with the M23 in its rural surroundings, the population of Goma increased by approximately 45 percent between 2012 and 2013 (Norwegian Refugee Council, 2014, p.6). In December 2013, 60,000 IDPs were estimated to be living in camps, 35,000 IDPs were living in host families, and an unknown number was living on their own. Officially, at least 11 percent of the population of Goma was considered to be IDPs (Norwegian Refugee Council, 2014, p.9, an employee of UN OCHA Kinshasa, 2016c). By October 2015, Goma's area had increased from 43.5 km² (2010) to 56.3 km², with one additional km² covered by five IDP camps.

The socioeconomic situation of Goma continued to be strongly affected by the settling of humanitarian agencies and military and civilian staff of MONUSCO, which brought their own personnel and attracted Congolese looking for job opportunities (Büscher and Vlassenroot, 2010). Additionally, Goma's population growth was fueled by an increase in deployment of the national army and police, who often brought along family members (Büscher, 2011, an employee of UN Habitat, 2016).

3.4 Summary

In our next visualization step, we produced maps using the vector data derived from our imagery and additional shapefiles, aiming to put events already researched by experts on the ground into their spatial contexts over time (i.e., Goma's spatial expansion).

The timeline in **Figure II-7** summarizes the sequence of conflict events and Goma's expansion from 1986 to 2015, displaying the correlation between phases of recurrent armed conflict and Goma's expansion through different waves of forced migration.

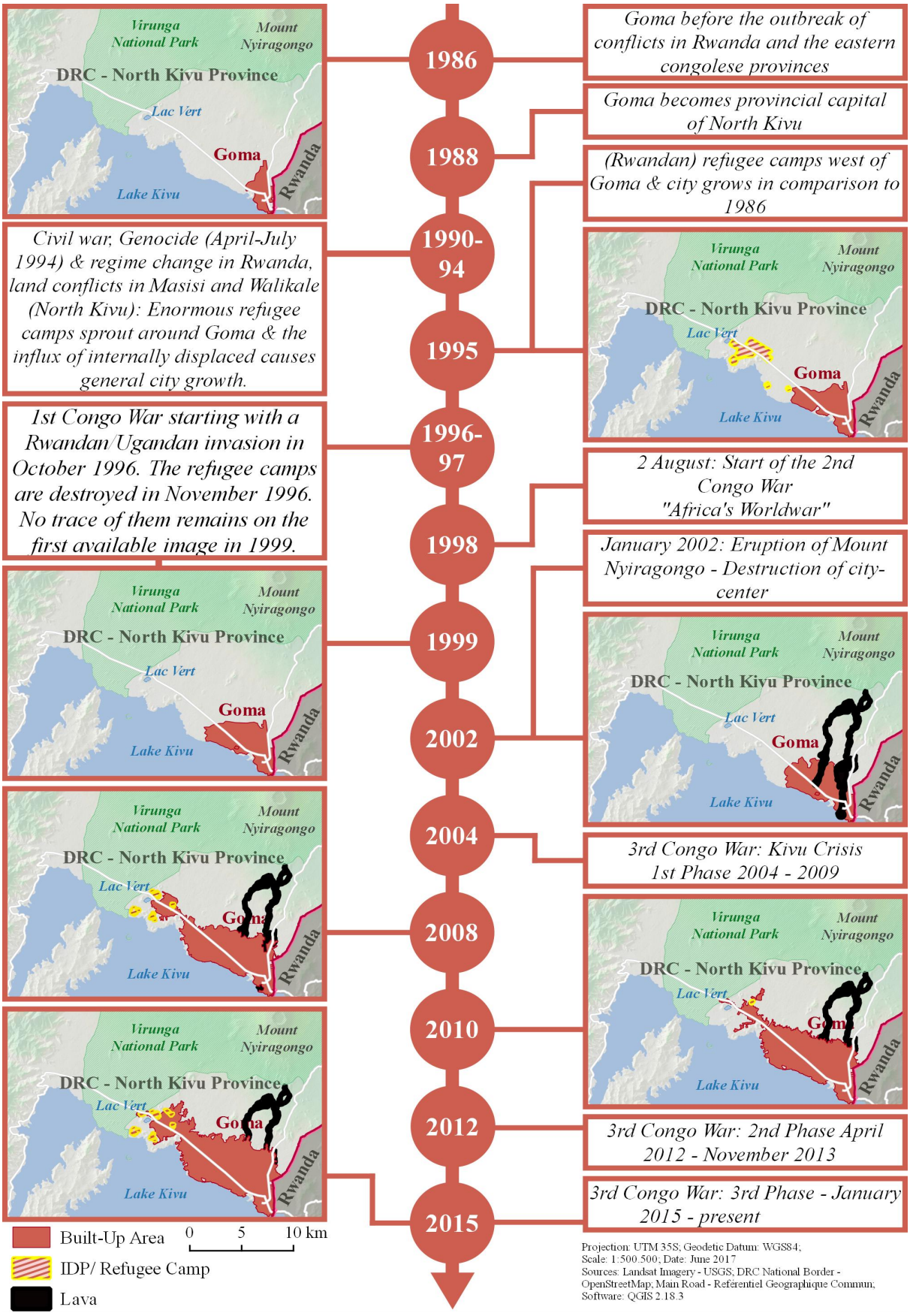

Figure II-7: Urban land change and influencing events

Goma's built-up area has been increasing continuously over time as displayed in **Table II-2**.

Table II-2

	Area in km² (rounded)	**Growth in %**
1986	7	
1989	8	14
1995	17	106
1999	20	20
2008	40	102
2010	44	9
2015	56	30

Based on our imagery, two different types of expansion of built-up area were identified: a continuous westward directed expansion and a fragmented development.

Goma's development has been strongly influenced by the armed conflicts in the Great Lakes region, mainly as a push factor for forced migration from rural areas to the city. The pull factors include the relative security and economic prosperity of Goma. Furthermore, and linked to the security situation, a large number of international humanitarian and peacekeeping personnel and an increasing number of national military contributed to Goma's general growth. The emergence of large refugee camps with people fleeing neighboring Rwanda, later succeeded by camps filled with internally displaced Congolese, and the closure and reopening of these camps caused the fragmented development of Goma's outskirts. As the city expanded westward, the camps began to merge slowly with the city. Furthermore, the eruption of the Nyiragongo volcano had an impact on Goma's development, causing internal displacement within the administrative area of the city and increasing the expansion of built-up area towards the west.

Results of earlier studies can be confirmed: Goma has been growing in an unplanned and fragmented fashion (Büscher, 2011, Verhoeve et al., 2004). Armed conflict has lead to a rural exodus, and cities with relative stability compared to their hinterlands grow and are sometimes converted into large urban centers (Verhoeve et al., 2004, Beall, 2007).

4 Discussion: Benefits and Limitations to Interpreting Field-Visit-Supported Visual Satellite Imagery

The described changes, based on visual image interpretation, are in themselves descriptive results. By combining them with both existing and newly conducted research, including interviews and site visits, we could trace underlying processes. While a distinct causal analysis would go beyond our data, this study deepens our knowledge on certain land-use developments, while remaining aware of limitations due to blurred individual expert knowledge of the past.

One goal of our approach was accessibility to non-experts of the field of remote sensing, while still making use of the added value of spatial data in combination with field research and being comprehensive in scope. For this reason, we applied the most basic method of analysis of satellite imagery from the toolkit of remote sensing.

Recent contributions of this field demonstrate how the constraints encountered in our simplified approach can be circumvented by applying highly sophisticated methodology[11] (Wilson, 2014, Baumann et al., 2014, Butsic et al., 2015, Luethje et al., 2014), by using data of much higher resolution (Kranz et al., 2017), or by applying different types of mixed-method approaches, such as the combination of space-borne and "human sensed" data from the ground (Rodriguez Lopez et al., 2017).

However, without profound specific training, these techniques are realistically not applicable for researchers outside the field of remote sensing. For this reason, a dialogue between the disciplines of remote sensing and urban and conflict studies would be a welcome future development.

Nevertheless, our study has demonstrated how even an "easy" approach can produce significant added value by complementing field research with the spatial and temporal dimension.

[11] Visual interpretation was limited by the spatial resolution of 30 m per pixel; more advanced analyses based on spectral information and automated algorithms could help to circumvent these limitations and cover larger areas. Additionally, the resulting data can be analyzed further by quantitative methods.

5 Conclusion

The analysis of Landsat data and the cartographic representation of the results of this analysis enabled us to inspect areas where field studies had not been continuously possible, or where, to date, much of the gathered information had not been spatialized and mapped. By adding a spatial perspective to existing information ("view from above") and by employing historical data ("view into the past"), we could shed light on trends of spatial expansion, while also uncovering several pathways for future analysis.

A similar approach might utilize higher-resolution imagery to reveal details of urban growth, such as quantity and structure of buildings and the density of built-up area as well as changes to this area. A follow-up to in-depth fieldwork could then explore causes and stakeholders behind these spatial developments, such as the precise location of IDP settlements, gentrification processes, or the development of slums.

Furthermore, our simplified approach could be applied to perform comparative studies in conflict contexts. Examples for the Goma case are as follows:

- inter-regional: Goma vs. Kisangani, a city especially hard-hit by the Congo Wars;
- intra-regional: Goma vs. Bukavu, both located in proximity of Lake Kivu and both sharing a border with Rwanda;
- intra-regional but trans-border: Goma vs. Gisenyi on the Rwandan side, both with a similar geographic location but with different political regimes;
- intra-regional but trans-border: Goma vs. Gulu in Uganda, both located within the Great Lakes region, but exposed to different types of warfare.

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Internally Displaced Persons Camps, western Goma (2014)

Chapter III:
Intraurban Development in a City under Protracted Armed Conflict: Patterns and Actors in Goma, DR Congo

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Abstract

Goma, the provincial capital of North Kivu in eastern Democratic Republic of the Congo (DRC) is the urban heart of a region that has been characterized by protracted violent conflict since the early 1990s. While several studies on Goma focus on sociodemographic and political processes or on areal development, our study unravels the effects of protracted armed conflict and gradual state withdrawal on Goma's urban development at a microlevel. The observation period of our analysis is 2005–2014, the time of several armed rebellions in the Kivu region or the so-called violent peace. Building on a mixed-methods approach, patterns and anomalies of urban development derived from very high resolution satellite images are combined with data gathered on the ground. The study starts from a city-scale analysis of urban expansion and densification trends earth-observation data and then uses earth-observation data-guided site selection for a detailed analysis, followed up by in-depth field research. We identify four major urbanization patterns in Goma's spatial development: forced displacement, humanitarian interventions, militarization, and church-based social action. These patterns are driven by four key urban players, which have been shaping Goma's cityscape throughout more than two decades of violent conflict. The insights generated here facilitate a better understanding of the complex intertwinement of spatial and political dynamics in a city located in a setting of violent conflict.

1 Introduction

Urban development[12] in sub-Saharan Africa has become a popular field of study over the past 20 years and has been extensively researched within urban studies, by disciplines such as geography, sociology, anthropology, architecture, and economics. One particular branch of urban studies has recently begun to examine the relationship between the dynamics of urbanization and the dynamics of war and violent conflict. This approach bridges findings from the majority of research that is conducted either on urban life and development (e.g., Murray and Myers, 2007, Simone, 2001, Myers, 2011) or on violent conflict by itself (e.g., Collier and Sambanis, 2005, Reno, 1999, De Waal, 2009, de Waal, 1996). Of the studies placing emphasis on the African continent, only few explore the nexus between cities and contemporary warfare (Wilson, 2014, Branch, 2013, Hoffman, 2007). While perceptions of warfare in Africa have mainly been shaped by a strong focus on rural areas, the role of urban areas in the myriad forms of conflict remain little understood; this calls for closer interaction between conflict studies and urban studies, as also noted by Beall and Goodfellow (2014), among others. A recently published collection of papers on the larger Great Lakes region explicitly aims to fill this academic gap (Büscher, 2011, Büscher, 2012, Verhoeve et al., 2004, Van Overbeek and Tamás, 2018, Mathys and Büscher, 2018).[13] With this article on the Democratic Republic of the Congo (DRC), home to our case-study city, we aim to contribute to filling this gap by explicitly investigating the relationship between urbanization and civil war.

Most academic research on urbanization in eastern DRC is based on qualitative approaches. To a certain extent, long-term ethnographic fieldwork is an answer to the lack of available "hard data" on urbanization tendencies in the DRC, where protracted war and state informalization have severely weakened the administrative apparatus. As a result, services related to demographics, cadastres, and urbanism are often run by unpaid and highly corrupt

[12] This article employs the term of *urban development* including aspects such as changes in urban land use, urbanization, urban growth, expansion, spatial development, and urban change processes.

[13]and JEAS special issue "African cities and violent conflict: the urban dimension of conflict and post-conflict dynamics in Central and Eastern Africa." See: https://www.tandfonline.com/toc/rjea20/12/2?nav=tocList

bureaucrats (De Herdt and de Sardan, 2015, Trefon, 2004), making obtaining demographic statistics a challenge. The demographic statistics that do exist are often outdated or inconsistent. This situation is at its worst in the Kivu provinces, which have been affected by conflict and a humanitarian crisis for more than 20 years. Consequently, scholars often employ methods such as interviews, focus group discussions, and mental maps to reconstruct the dynamics of urban growth and demographic or spatial transformation. This methodological approach contributed to a series of well-documented case studies that provided rich qualitative data on the impact of forced displacement on urban growth, the effect of war economies on rural-urban transformation, and the ethnic character of land disputes related to urban expansion. However, the lack of quantitative and spatially explicit cadastral and statistical data and accurate maps leaves an important gap regarding spatial patterns of urban expansion.

To collect quantitative and spatial data on intraurban development patterns, very high resolution (VHR) satellite imagery has proven useful in several studies (Bachofer, 2016, Bouziani et al., 2010). The addition of the perspective from above facilitates an accurate understanding of urbanization in the context of violent conflict in both methodological and analytical terms. It contributes to filling the "hard data" gap and helps to circumvent political and security challenges.[14] In complex research contexts the use of satellite imagery can help to resolve two dilemmas: Proximity in space through going into the field, exposing oneself to insecurity and the constant need (and often inability) to negotiate access[15]. Proximity in time by going into the field, which is often not possible during periods of open conflict. Time series allow us to look into the past and visualize developments that would have otherwise remained unnoticed. Furthermore, satellite imagery enables researchers to visualize large areas, facilitating measurability and the identification of specific patterns. In the context of armed conflict coarser (Landsat) satellite imagery has been used to gather data on land-use change, de- and reforestation, and the expansion of settlements during and after conflict (Wilson and Wilson, 2013, Lidow, 2010, Baumann et al., 2014, Butsic et al., 2015, Wilson,

[14] For eastern DRC, Vlassenroot (2006) elaborates on these challenges.

[15] For example, during one field trip in 2016, access was denied to our researcher at the border post between Rwanda and the DRC. We then invited relevant interview partners from Goma to Gisenyi (Rwanda). Satellite imagery was then used to discuss specific urban developments together with these interviewees without needing to be physically present at that locality under discussion.

2014). However, to analyze spatial processes such as urban growth, qualitative data collection on the ground is required; it enables researchers to understand the political, socioeconomic, and cultural dynamics behind spatial processes and is thus much more than simple "bottom-up validation" for satellite imagery (Jiang, 2003, De Vos et al., 2008).

This article aims to address the two aforementioned gaps: the analysis of war-induced urbanization on the intraurban level and the methodological combination of (VHR) satellite imagery interpretation and fieldwork, that has only rarely been applied in conflict contexts. It draws on the data and methodological approach of Pech and Lakes (2017), but changes the analytical focus from historical conflict patterns on the macro-level to micro-level urban development changes induced by four key actors active on the ground. We emphasize the utility of leveraging freely available tools and easy-to-acquire data to study individual cases of spatial development and the actors involved, rendering it also possible to non-experts in geodata processing, to link even individual histories to spatial trajectories. For our case study, we choose the city of Goma in eastern DRC. We examine Goma's urban development for the period 2005-2014, during which the city experienced several important episodes of armed conflict. Our study examines how anomalies in an urban built-up area can inform us about the dynamics and actors behind urban development in a context of violent conflict.

Our research follows three steps. First, we conduct a macro analysis (i.e., city-scale) of urban expansion and densification trends in Goma using VHR satellite imagery. Second, we analyze our data on the level of individual building structures to visually identify distinctive evolutionary patterns in the urban fabric. Four patterns of built-up structures appear to stand in particular contrast to their respective environment. Third, we conduct qualitative research (visits and interviews) at these sites in order to reveal the multiple forms of agency and key actors involved in shaping Goma's rapidly evolving cityscape. We find that our selected sites represent four major settlement tendencies that have characterized Goma's growth throughout decades of armed conflict: forced displacement, humanitarian urbanism, militarization of the cityscape, and church-based provision of social infrastructure.

2 Goma: The Urban Heart of Congo's Kivu Conflict

Due to its profile as the urban heart of the ongoing violent conflict in eastern DRC, Goma has received attention from researchers from different disciplines in the past few years.[16] The city is located in an area afflicted by armed conflict since the early 1990s and is marked by dynamic and mostly unplanned (informal) urban growth. Goma is situated in the western branch of the East African Rift System. It borders Rwanda to the east and Lake Kivu to the south and lies south of the active volcanoes Mount Nyiragongo and Mount Nyamulagira. Goma has an estimated 1.1 million inhabitants (Mairie de Goma, 2016).

[16](Political) geographers: DOEVENSPECK, M. 2011. Constructing the border from below: Narratives from the Congolese–Rwandan state boundary. *Political Geography,* 30**,** 129-142, VERHOEVE, A., VLASSENROOT, K. & RAEYMAEKERS, T. 2004. Conflict and the urban space: The socio-economic impact of conflict on the city of Goma. *Conflict and social transformation in Eastern DR Congo***,** 103-22.; anthropologists: OLDENBURG, S. 2012. A Goma On Sait Jamais. Jugend, Krieg und Alltag in Goma, DR Kongo. *PhD diss., University of Bayreuth*., TREFON, T. & KABUYAYA, N. 2016. Précarité et bien-être à Goma (RDC): récits de vie dans une ville de tous les dangers., and Hendriks (2018); conflict studies: BÜSCHER, K. Urban governance beyond the state: practices of informal urban regulation in the city of Goma, Eastern DR Congo. Urban Forum, 2012. Springer, 483-499, BÜSCHER, K. 2011. *Conflict, state failure and urban transformation in the Eastern Congolese periphery: The case of Goma.* Ghent University, BÜSCHER, K. & MATHYS, G. 2013. Navigating the Urban 'In-Between Space': Local Livelihood and Identity Strategies in Exploiting the Goma/Gisenyi Border. *Violence on the Margins: States, Conflict, and Borderlands. New York: Palgrave Macmillan***,** 119-142, VLASSENROOT, K. & BÜSCHER, K. 2013. Borderlands, identity and urban development: the case of Goma (Democratic Republic of the Congo). *Urban Studies,* 50**,** 3168-3184, VLASSENROOT, K. & BÜSCHER, K. The border city of Goma: zone of contestation or laboratory of change? Urban International Conference Poverty in Medium and Small Cities of Developing Countries, 2011. Koninklijke academie voor overzeese wetenschappen, 161-178.; geophysicists: TEDESCO, D., VASELLI, O., PAPALE, P., CARN, S., VOLTAGGIO, M., SAWYER, G., DURIEUX, J., KASEREKA, M. & TASSI, F. 2007. January 2002 volcano-tectonic eruption of Nyiragongo volcano, Democratic Republic of Congo. *Journal of Geophysical Research: Solid Earth,* 112, FAVALLI, M., CHIRICO, G., PAPALE, P., PARESCHI, M., COLTELLI, M., LUCAYA, N. & BOSCHI, E. 2006. Computer simulations of lava flow paths in the town of Goma, Nyiragongo volcano, Democratic Republic of Congo. Ibid.111, SMETS, B., TEDESCO, D., KERVYN, F., KIES, A., VASELLI, O. & YALIRE, M. M. 2010. Dry gas vents ("mazuku") in Goma region (North-Kivu, Democratic Republic of Congo): Formation and risk assessment. *Journal of African Earth Sciences,* 58**,** 787-798..

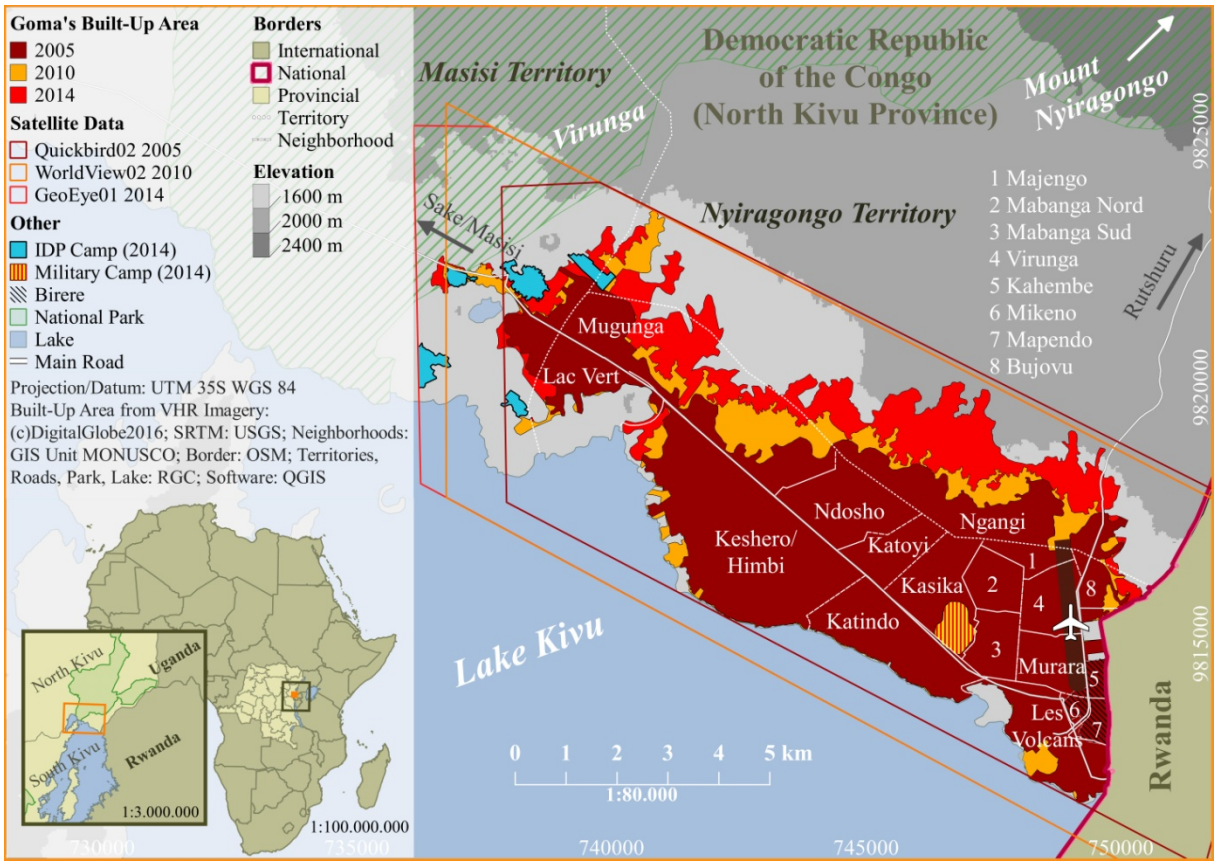


Figure III-1. Goma neighborhoods and built-up area, 2005, 2010, and 2014; Goma IDP camps, 2014

Since the 2006 elections, eastern DRC has seen its security situation deteriorate and has become a highly fragmented militarized landscape of armed groups mobilized by conflict issues of land, identity, and political representation. The impact of this protracted crisis on Goma's development has resulted in political, socioeconomic, and spatial urban transformations that have assigned the city a variety of identities: the headquarters of the political economy of war, the vibrant center of a large humanitarian industry, and the safe haven for refugees and internally displaced persons (IDPs) (Büscher, 2011, Büscher, 2016). Political and military instability has resulted in a general urban life in uncertainty and risk (Oldenburg, 2012), which is reinforced by the city's geography (Trefon and Kabuyaya, 2016). The eruption of Mount Nyiragongo in January 2002 destroyed 14,000 buildings in the city center and had a strong influence on Goma's development (Kanene, 2014, p. 30). Its close proximity to Lake Kivu also exposes parts of the city to toxic and explosive gases, a by-product of volcanic activity, emerging from the lake water.

The impact of conflict and state failure on Goma's development has been investigated from various disciplinary angles and mostly based on fieldwork. Büscher (2011) and Oldenburg (2012) analyze the effects of violent conflict on socioeconomic, political, and spatial processes of urbanization. Büscher and Vlassenroot (2010) investigate the socioeconomic

impact of the humanitarian industry and reveal how the presence of high-salaried international employees has accelerated urban gentrification. Verhoeve et al. (2004) focus on the arrival of IDPs and describe Goma as a place of relative security. Doevenspeck and Nene (2012) and Büscher and Mathys (2013) examine the impact of informal cross-border trade between Goma and its Rwandan twin town Gisenyi. Bompangue et al. (2009) look at the epidemiological consequences of war for Goma's inhabitants, while Biswas and Tortajada-Quiroz (1996) explore the ecological impact of large numbers of refugees in Goma's outskirts after the Rwandan genocide. Meanwhile, political geographers connect the Kivu region's violent conflicts to (i) disputes over land, (ii) the political history of the DRC-Rwanda border, (iii) the presence of conflict minerals, or (iv) struggles over territorial identity and autochthony . Büscher (2016) draws on Goma's recent urbanization to present a spatial reading of broader patterns of war and peace in eastern DRC. In his article on transborder economic activities between Goma and Gisenyi Doevenspeck (2011) illustrates Goma's growth between 1981 and 2009 based on Aster satellite imagery (15 m^2–90 m^2 resolution). Using a volcanic risk map based on Landsat ETM+ imagery (15 m^2–30 m^2), Di Martino et al. (2007) find that Goma's entire area is endangered by potential lava flows.

3 Methodology and Data

Goma's spatiotemporal development characteristics were analyzed using very high resolution (VHR) imagery from 2005, 2010, and 2014; topographic maps from 2003 and 2012; qualitative interviews with urban stakeholders and expert interviews in Kinshasa, Rwanda, Belgium, and Germany; and site visits in Goma (**Table III-1**).

Table III-1. Data

Data and Source	Characteristics	Use
Satellite Raster Data		
Quickbird02 Digital Globe	Bands 1–4: 2.4 m, Pan: 0.6 m 2005/02/18 coregistered to WorldView02 (2010), ortho image based on SRTM	Visual interpretation, building extraction
WorldView02 Digital Globe Foundation	Bands 1–8: 2 m, Pan: 0.5 m 2010/01/29 Mosaic, pan-sharpened, ortho image	
GeoEye01 Digital Globe Foundation	Bands 1–4: 2 m, Pan: 0.5 m 2014/04/02 mosaic, pan-sharpened (0.5 m), ortho image, coregistered to WorldView02 (2010)	
SRTM DEM NASA	Elevation at 30 m ground sampling distance (2000)	Orthorectification of Quickbird02 imagery (2005), cartography
Additional Geodata		
OpenStreetMap vector data (buildings)	2005	Basis vector data for further digitization
Topographic map BCD Goma/Service de Cadastre	1:10.000 2003	Neighborhood-boundary extraction
Topographic map GIS unit MONUSCO	1:11.000 2012	Orientation, identification of MONUSCO/military sites
(Analogue) mental map of Goma's neighborhoods Croix Rouge Congolaise	2016	Basic orientation during interviews/structuring along neighborhoods, with locals with little map/image interpretation experience
Boundaries, infrastructure Referentiel Geographique Commun (RGC)	2015–2016	Cartography
Interviews and Site Visits		
Interviews with UN and NGO staff, national and provincial administration, religious and educational institutions, informants with a long residency in Goma	2008–2016	Background and in-depth information on Goma's development
Site visits in Goma: neighborhoods, private homes, military and IDP camps, churches, social centers, schools	2016	Gathering knowledge on sites identified in the geodata

We complemented qualitative fieldwork data from 2016 with fieldwork data on the dynamics of war-induced urbanization gathered after 2008. The geodata enabled the preselection of sites to visit, supported fieldwork and expert interviews, and facilitated mapping (**Figure III-2**).

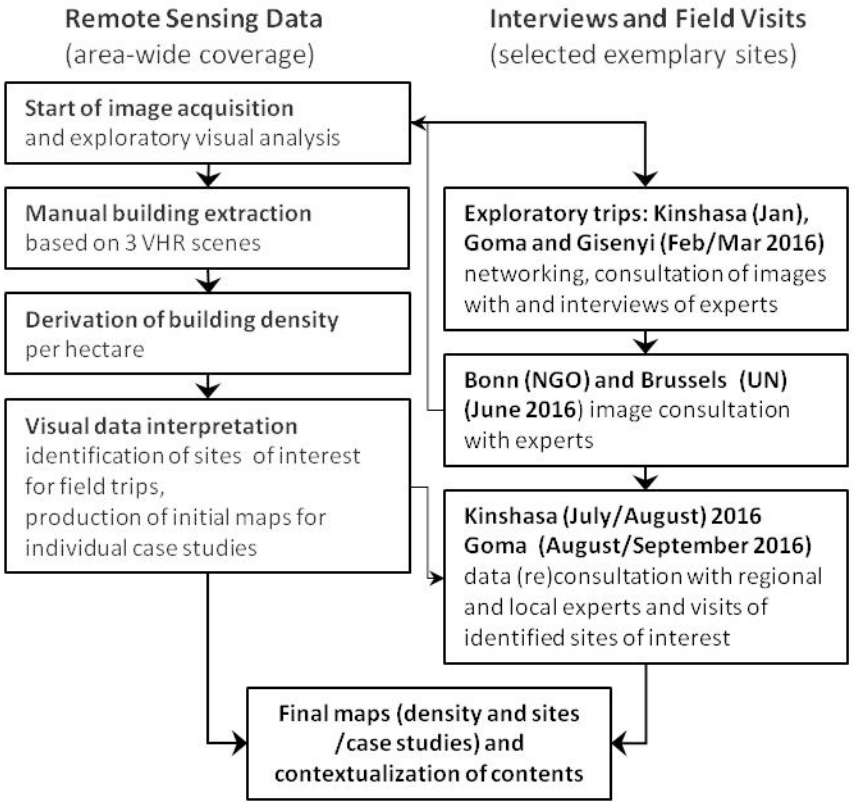


Figure III-2. Workflow Based on Satellite Imagery Analysis, Mapping, and Fieldwork Records

3.1 Image Preprocessing

Due to a scarce coverage of our study region, we used imagery from three different commercial earth observation satellites. The radiometrically corrected data from 2010 and 2014 was delivered orthorectified. For 2005, we used the 30 m resolution Shuttle Radar Topography Mission (SRTM) DEM for image orthorectification. The 2005 and 2014 images were coregistered to the 2010 image with 202 visually identified ground control points. All data were projected to WGS 84 UTM zone 35S (EPSG:32735). To improve the visual interpretability, the multispectral image bands were pan-sharpened in ERDAS IMAGINE

2015 using the specific methods recommended by the ERDAS developers for the respective sensor model (Subtractive Resolution Merge for Quickbird, Projective Resolution Merge for WorldView02 and GeoEye01).

3.2 Building Extraction and Visual Interpretation

We applied a collaborative manual digitization approach that allowed us to best contextualize and integrate the information provided by (i) the raster sources with different spatial resolutions, (ii) existing vector data from OpenStreetMap (OSM), and (iii) supplementary topographic maps. Most of Goma's buildings already existed in OSM, based on an image of 2010. We defined a grid of 135 1 km x 1 km cells as a framework for digitalization tasks, assessed this building-layer, and corrected it using the Java OpenStreetMap Editor (JOSM). Eleven image interpreters added missing buildings based on our image from 2010 and analogously generated building layers for 2014 and 2005 by adding or erasing polygons. As image displacement after co-registration remained locally at up to 3 m for 2014 and 2 m for 2005, buildings for 2014 and 2005 were digitized based on the respective image and then aligned with the 2010 data. The results were three vector layers with individual buildings for 2005, 2010, and 2014. No omitted or committed buildings were revealed following validation, for which building data for each year were chosen from 10 randomly selected digitization grid-cells.

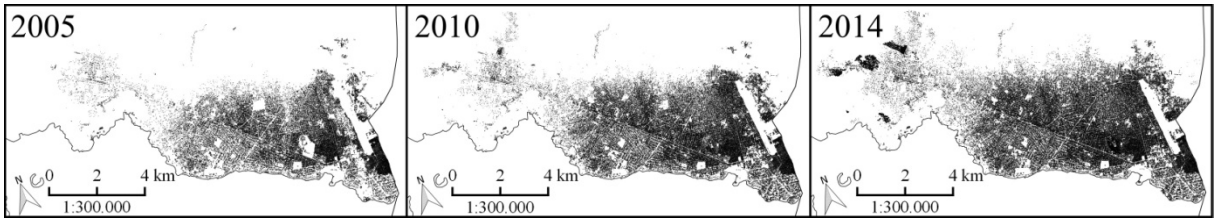


Figure III-3.Vector Layers with Individual Buildings Extracted from Imagery and OSM Data

To minimize inaccuracies due to potential image displacement, and to derive the building density per hectare, we aggregated the building data to a vector grid of 100 m x 100 m cells and counted the number of building centroids per cell. We similarly calculated the buildings and building density per neighborhood based on outlines digitized from the scanned topographic map of 2002/2003.

We analyzed building and density maps for the entire city to visually identify patterns of interest. The common criterion for visual interpretation was contrast – that is, the sharp separation of an area from its surroundings with an abrupt change in (1) building density, (2) alignment of structures, such as geometric versus organic patterns, and (3) density and/or alignment over time.

It is important to note that in all cases these characteristics are difficult to perceive on the ground, regardless of how stark the respective contrast is visible from above. For example, some sites are surrounded by security walls and therefore not visible. With such locations being integrated into their surroundings, it is hard to notice their boundaries.

3.3 Qualitative Fieldwork

We conducted interviews and informal conversations with various stakeholders (**Table III-1** and **Figure III-2**). Topics included the socioeconomic, political, and humanitarian situation in eastern DRC; urban development and influencing institutions and factors; and Goma's historical development. The satellite imagery, as well as topographic and mental maps of Goma, was used to order and secure expert knowledge on specific built structures. Furthermore, we focused on the city's spatial development and events that were considered to have had a major impact. Interviews were complemented by visits to areas of the city identified as of particular interest in our data or pointed out by interviewees. The trips included visiting individual homes and interviewing inhabitants, sometimes with the aid of a translator (e.g., Swahili into French).

In order to accurately situate this research and its data analysis, we additionally provided contextual background by drawing on insights from long-term qualitative fieldwork carried out by one of the authors between 2008 and 2015. This data revealed general trends in Goma's urban transformation during different episodes of Kivu's violent conflict. It provided useful information on the main driving forces behind Goma's expansion, the impact of forced displacement on urban growth, and the different actors involved in Goma's urbanization processes.

4 Goma's Urban Growth, 2005-2014

The investigated period of 2005–2014 corresponds to two major episodes of violence intensification in North Kivu. The findings from 2005 display the situation in Goma before the start of the so-called Kivu war, which resulted from contestations following the 2006

election and led to the armed mobilization of the CNDP rebel movement,[17] whose clashes with other armed actors, as the Armed Forces of the Democratic Republic of the Congo (FARDC) and peacekeepers belonging to the UN Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO) forcefully displaced many in 2008 and 2009. In 2010 the images show the urban consequences for the built environment. Finally, in 2014 they display the consequences of another turbulent period: the M23 rebel movement[18] attempted to secure territorial control in North Kivu, again leading to forced displacement into urban areas. **Table III-2** gives an overview of the growth of Goma's built-up area. **Table III-3** provides detailed information for the neighborhood level.

Table III-2. Development of Buildings in Goma, 2005–2014

	City surface (ha)	Buildings	Buildings per ha	Built-up surface (ha)	% of city area
Goma 2005	3,900	57,087	14.6	415	11 %
Goma 2010	4,301	91,596	21.3	637	15 %
Goma 2014	5,664	114,812	20.3	796	14 %

Table III-3. Development of Neighborhoods in Goma, 2005–2014

		Buildings		Buildings 2010		Buildings 2014	
Neighborhood	Size (ha)	total	per ha	total	per ha	total	per ha
Bujovu	338	2,064	6.1	3,504	10.4	6,210	18.4
Majengo	211	3,875	18.4	6,609	31.3	7,144	33.8
MabangaSud	115	4,261	37.1	4,424	38.5	4,609	40.1
MabangaNord	118	2,870	24.3	3,310	28.0	3,611	30.6
Virunga	140	1,616	11.5	2,890	20.6	2,985	21.3
Murara	144	2,118	14.7	2,511	17.4	2,465	17.1
Kahembe	49	1,950	39.8	1,949	39.8	2,042	41.7
Mikeno	24	939	39.1	919	38.3	905	37.7
Mapendo	45	2,592	57.6	2,419	53.8	2,282	50.7
Kasika	319	5,411	17.0	10,155	31.8	12,047	37.8
Katoyi	214	6,330	29.6	5,963	27.9	7,547	35.3
Ndosho	759	6,330	8.3	11,406	15.0	17,165	22.6
Volcans	286	2,056	7.2	3,190	11.2	3,144	11.0
Katindo	353	5,406	15.3	7,111	20.1	7,584	21.5
Himbi+Keshero	971	8,867	9.1	15,108	15.6	17,720	18.2
Lac Vert	349	709	2.0	904	2.6	2,077	6.0
Mugunga	1,229	2,373	1.9	9,224	7.5	15,275	12.4

[17] Congrès National pour la Défense du Peuple (National Congress for the Defense of the People), led by General Laurent Nkunda

[18] Mouvement du 23 Mars (March 23 Mouvement), led by Colonel Sultani Makenga VOGEL, C. 2014. Islands of Stability or Swamps of Insecurity? *Africa Policy Brief*, 1-2.

In February 2005 Goma had 57,087 buildings, with the highest concentration in the area of Birere, which consists of the neighborhoods Mapendo, Kahembe, and Mikeno. This former *cité indigene* (or "indigenous quarter" as referred to during colonial times) is characterized by a vibrant informal economy and often locally portrayed as a slum. Located along the Rwandan border, Birere has been densely populated since the Belgian colonial era due to its direct access to transborder commercial activities and to infrastructure, such as electricity, roads, and water (Büscher and Mathys, 2013).

By January 2010, the number of buildings in Goma had increased to 91,596. Most of this growth took place in the central neighborhoods Majengo, Virunga, and Mabanga Sud and within 1 km of the main road that heads west towards Katoyi, Ndosho, and Mugunga. However, buildings close to the lakeshore south of the main road remained scattered. Additional growth occurred at the Mugunga III IDP camp in the west, with 592 tents. IDPs came primarily from the Masisi and Rutshuru territories, arriving via the two entry roads from the west and north. Many headed for the overcrowded central neighborhoods, where they had more livelihood opportunities without incurring the costs of transportation. Others head for the peripheral neighborhoods at the city's western entry point. This led to an urban expansion westwards and the creation of new peri-urban neighborhoods (Büscher, 2011). When comparing geodata from 2005 and 2010, we observe an increase in built-up surface in the Katindo military camp in Kasika, where the number of buildings went from 152 to 2,209.

By April 2014, Goma had 116,278 buildings. Building density had increased in all the aforementioned areas, except for Mapendo in Birere, where 310 houses had disappeared. The Katindo military camp now had 3,291 buildings, while Mugunga III now contained 2,981 tents. In addition, four more IDP camps had been set up (Mugunga I: 5,359 tents; Lac Vert: 1,784 tents; Bulengo 168 tents; Buhimba: 1,426 tents).

This trend is demonstrated in the density maps in **Figure III-4**.

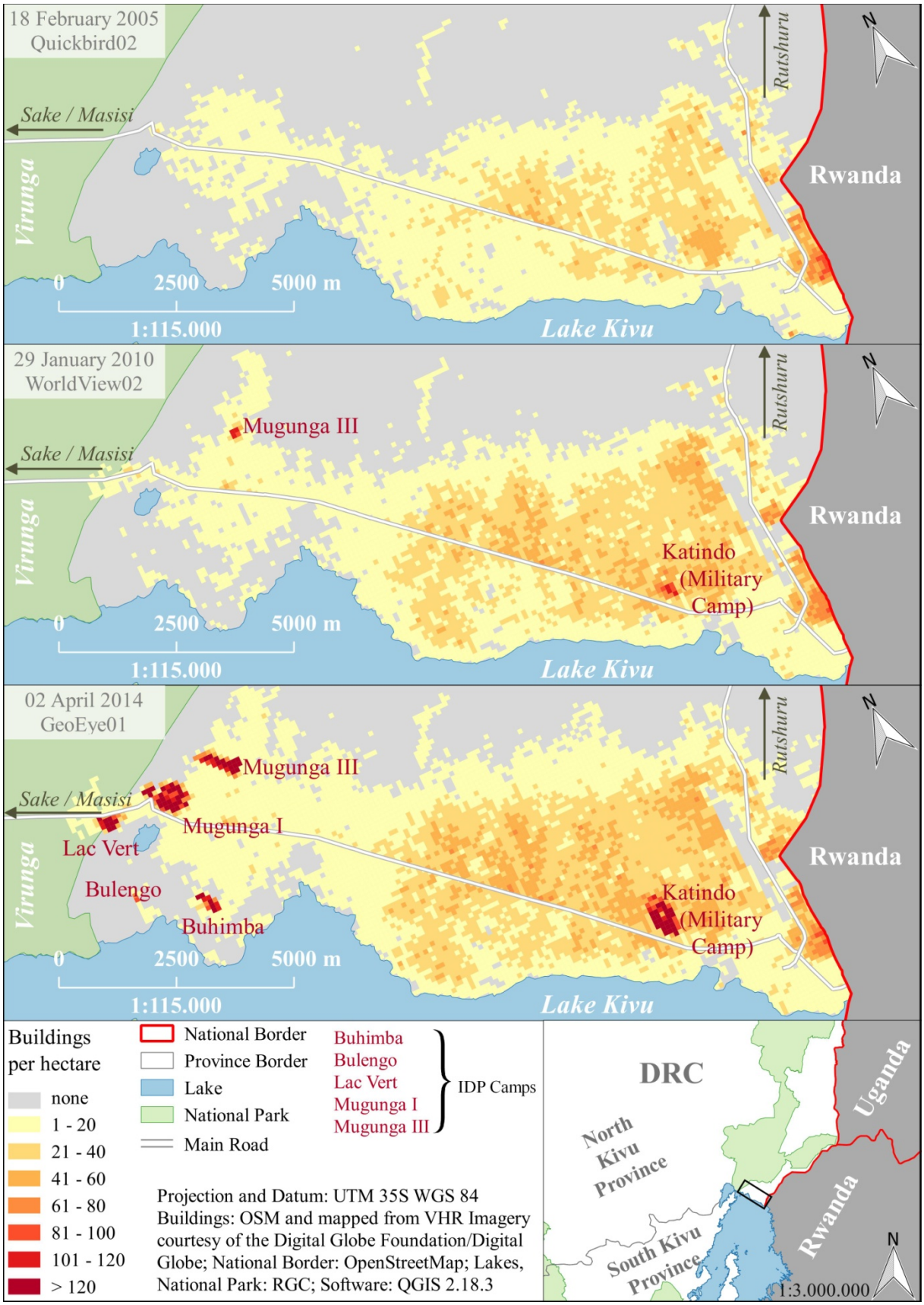


Figure III-4. Building Density, 2005, 2010, and 2014

The comparison of the three building layers and density maps reveals a westward urban expansion and that growth rates and patterns differ between neighborhoods. Goma's built-up area becomes denser towards the Rwandan border, specifically in Birere, which can be explained by the fact that this area offers livelihood opportunities. Birere enjoys transborder commerce, while neighboring Les Volcans – a former Belgian residential and administrative neighborhood and one of the wealthiest and most expensive neighborhoods – hosts the offices of many international NGOs and UN agencies and homes of their employees. Les Volcans has remained relatively stable in its loosely built-up structure.[19] The data confirms that urban expansion is occurring along the two axes towards Masisi in the west and Rutshuru in the north. Built-up area becomes less dense towards Lake Kivu's shore and the western and northern periphery. The direction of Goma's expansion is driven by geographic and political constraints: to the north, uneven terrain, poor access to the lake and to groundwater, and the administrative city border render new constructions less attractive. This explains the high building density within a 1 km fringe on the north side of the westbound road.[20] On the south side of this main road, the terrain becomes more expensive due to its attractive proximity to the lakeshore.[21] To the east, the Rwandan border inhibits further expansion. The dark tones in the maps of 2010 and 2014 in **Figure III-4** display the concentration of tents in the IDP camps in Goma's west and the densification of huts in the central Katindo military camp.

4.1 Four Dominant Phenomena of Urban Development in a Context of Crisis and Conflict

During our visual interpretation of the vector data, we identified the following built-up patterns (**Table III-4**): (1) densely and geometrically aligned agglomerations of small buildings that developed in Goma's loosely built western periphery, (2) an almost empty space in the center, which was converted into a densely, organically built-up zone, (3) a low

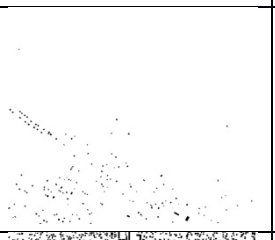
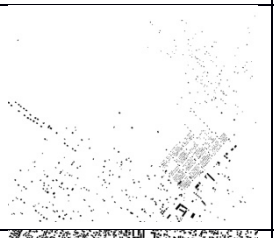
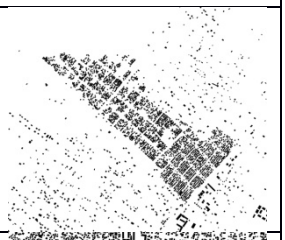
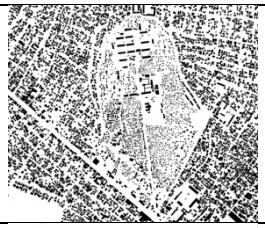
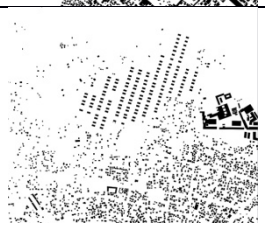
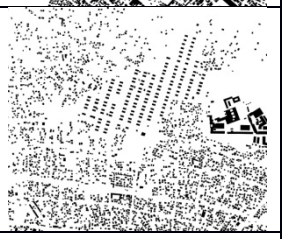
[19] Interviews with AN INHABITANT OF GOMA 2016. Interview # 13, several interviews with the same interviewee. *In:* PECH, L. (ed.), AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*

[20] Interviews with AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise*, AN EMPLOYEE OF THE PROVINCIAL MINISTRY OF URBAN PLANNING 2016b. Interview # 43, Informal background talk *In:* PECH, L. (ed.), AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*

[21] Interviews with AN INHABITANT OF HIMBI - GOMA 2016. Interview # 41, in Himbi. *In:* PECH, L. (ed.), A CONSULTANT FOR UN HABITAT 2016. Interview # 47, Skypeinterview. *In:* PECH, L. (ed.).

density of built-up area along the lakeshore, which stayed stable over time, and (4) the development of a geometrically ordered settlement close to the northbound main road, surrounded by organic city growth.

Table III-4. Examples of Patterns of Built-Up Structures

Pattern	2005	2010	2014
(1) Densely built and geometric alignment; growth over time			
(2) Densely built, organic structures; densification over time			
(4) Geometrically aligned small houses with gardens/space in between buildings; apparently planned growth over (a short period of) time			
(3) Examples (same year and scale) of contrast between: Spacious ground plots (left), in contrast to average density of built-up area (right); stability of density over time	2014 	2014 	

Starting from these observations, we identified four major urbanization tendencies in Goma's recent history: forced displacement, humanitarian urbanism, militarization of the cityscape, and church-based social action. These can be linked to four main groups of actors: IDPs, donor agencies and humanitarian organizations, military actors (mainly FARDC and MONUSCO), and Christian churches. Our analysis highlights and documents these four tendencies in further detail; though we do not claim that they represent an exhaustive picture of the dominant tendencies explaining Goma's urban development over the past 25 years. Other dynamics such as urban development related to the trade in natural resources have been extensively documented by Vlassenroot and Büscher (2013), for example.

(Forced) Displacement: The City as a Space of Refuge

Goma has been a central reception point for refugees and IDPs during almost three decades of conflict in the Great Lakes region. Its position as a "city of refuge and protection" started in 1994 with the massive influx of Rwandan refugees[22] and continued throughout subsequent episodes of violent conflict. In 2009 around 120,000 IDPs were in Goma alone (Pole Institute, 2009). By the end of 2010, around 900,000 people had been displaced in North Kivu (Holmes, 2010).

The arrival of IDPs in Goma had the dual spatial impact of prompting the erection of camps in the city's periphery and a demographic concentration in particular neighborhoods. Goma became an attractive zone of refuge as lower levels of insecurity and the concentration of humanitarian agencies ensured that they enjoyed relatively good levels of humanitarian assistance compared to rural areas (Büscher, 2011). Other scholars, as Branch (2013) and Bakewell and Bonfiglio (2013), have identified similar dynamics in urban impact of forced displacement in the Great Lakes region and Eastern Africa. Bakewell and Bonfiglio (2013) rightfully stress that, even during moments of intense instability, not all rural-urban displacement is conflict related, and it is important to recognize cities as both safe havens and centers of livelihood opportunities.

In 2014 IDPs accounted for 11 per cent of Goma's population (Norwegian Refugee Council, 2014). Another pull factor to Goma for IDPs was that it offered greater housing safety (Norwegian Refugee Council, 2014). Only a minority of IDPs stayed in camps, while the majority settled in the city itself, with relatives or other hosts. Whereas the urban environment offers better social links and economic opportunities, camps exhibit notoriously poor conditions, such as a lack of space and the prevalence of illness (IDMC, 2014, Koddenbrock, 2015).[23] Additionally, there is an increasing tendency by the provincial authorities to discourage settlement in IDP camps (Human Rights Watch, 2010). Given the protracted nature of displacement in this region, many IDPs eventually settle permanently in Goma, renting or purchasing property (Büscher, 2011, Norwegian Refugee Council, 2014).

[22] The situation in Goma during the refugee crisis in the summer of 1994 has been described in detail by CHAULIA, S. S. 2002. UNHCR's relief, rehabilitation and repatriation of Rwandan refugees in Zaire (1994-1997). *Journal of Humanitarian Assistance*. and MAMDANI, M. 2001. When victims become killers. *Princeton: Princeton UP*.
[23] This was also noted in 2009 during interviews and focus group discussions with IDPs in Goma in 2009.

Fieldwork in 2009 and 2016 revealed that IDPs often prefer to stay in the central neighborhoods, where there is basic urban infrastructure.[24]

The maps in **Figure III-5** and **Figure III-6** show examples of the main IDP settlement types: in camps, independently or in host families. Like all of Goma's IDP camps, Mugunga III is characterized by a densely built-up surface with small individual housing structures (**Figure III-5**). Mugunga III saw the number of tents increase from 592 tents in 2010 to 2,981 in 2014. IDP camps vary in size and structure according to when they started to be managed by a humanitarian organization.[25]

[24] Focus group discussion with IDPs in Ndosho, December 2009; interviews with an UNHRC officer, November 2009;AN INHABITANT OF GOMA 2016. Interview # 13, several interviews with the same interviewee. *In:* PECH, L. (ed.), AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*

[25] Interview with AN EMPLOYEE OF UN OCHA KINSHASA 2016c. Interview # 11, UN OCHA headquarters. *In:* PECH, L. (ed.) *UN OCHA.*

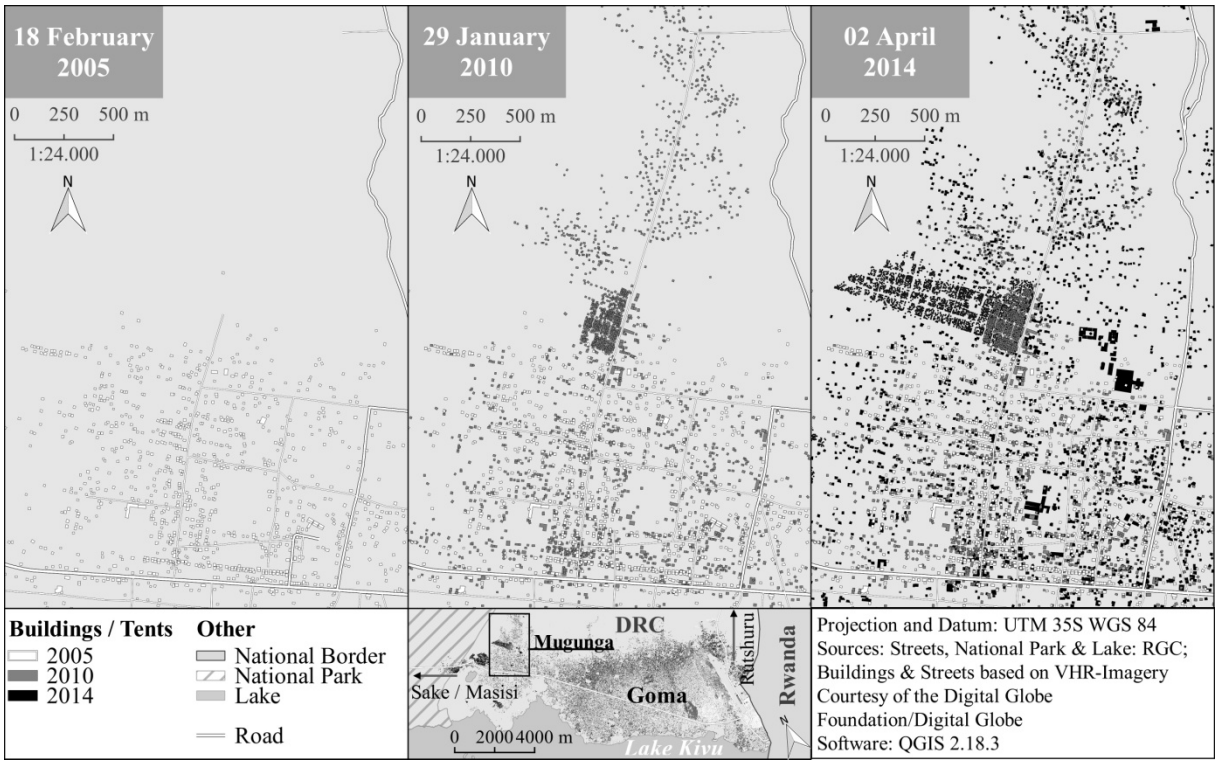


Figure III-5. General Increase of Buildings and IDP Camp Development in Mugunga Neighborhood, 2005, 2010, and 2014

Some IDPs settle individually and are thus partly responsible for the increase of buildings around the camp.[26] Those without social ties to inhabitants in the central neighborhoods and those who possess the means to rent or buy a small house and parcel of land often settle in Goma's western peripheral neighborhoods (Mugunga, Lac Vert), where house prices are relatively cheap (Büscher, 2011, p.97). Nevertheless, ownership rates are low among IDPs, and rental contracts are often for less than three months (Norwegian Refugee Council, 2014). The relatively loosely built-up structure of these neighborhoods facilitates small-scale urban agriculture (Büscher, 2011, p.97),[27] which is an important source of self-subsistence for IDPs, as the majority lack regular employment.[28]

[26] Interview with AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise.*
[27] Interview with AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*
[28] Interview with AN INHABITANT OF MUGUNGA 2016. Interview # 51, in Mugunga. *In:* PECH, L. (ed.).

The majority of IDPs in North Kivu (62–86 percent) live with host families (Rohwerder, 2013, p.39, Simpson, 2010). This common type of IDP settlement is naturally difficult to detect through satellite imagery.

Figure III-6 illustrates the individual settlement of an IDP family and its subsequent function as a host family. By analyzing in detail a representative development of one particular housing plot (in the center of the box) we can extrapolate the typical evolutionary path of other similar housing complexes and thus of the built-up area in the neighborhood of Ndosho, which is located between Mugunga and the city center. It reveals a complex story of forced migration within the Great Lakes region, North Kivu, and Goma, and a combination of individual families purchasing small parcels and houses and then subsequently taking in members of the (extended) family.

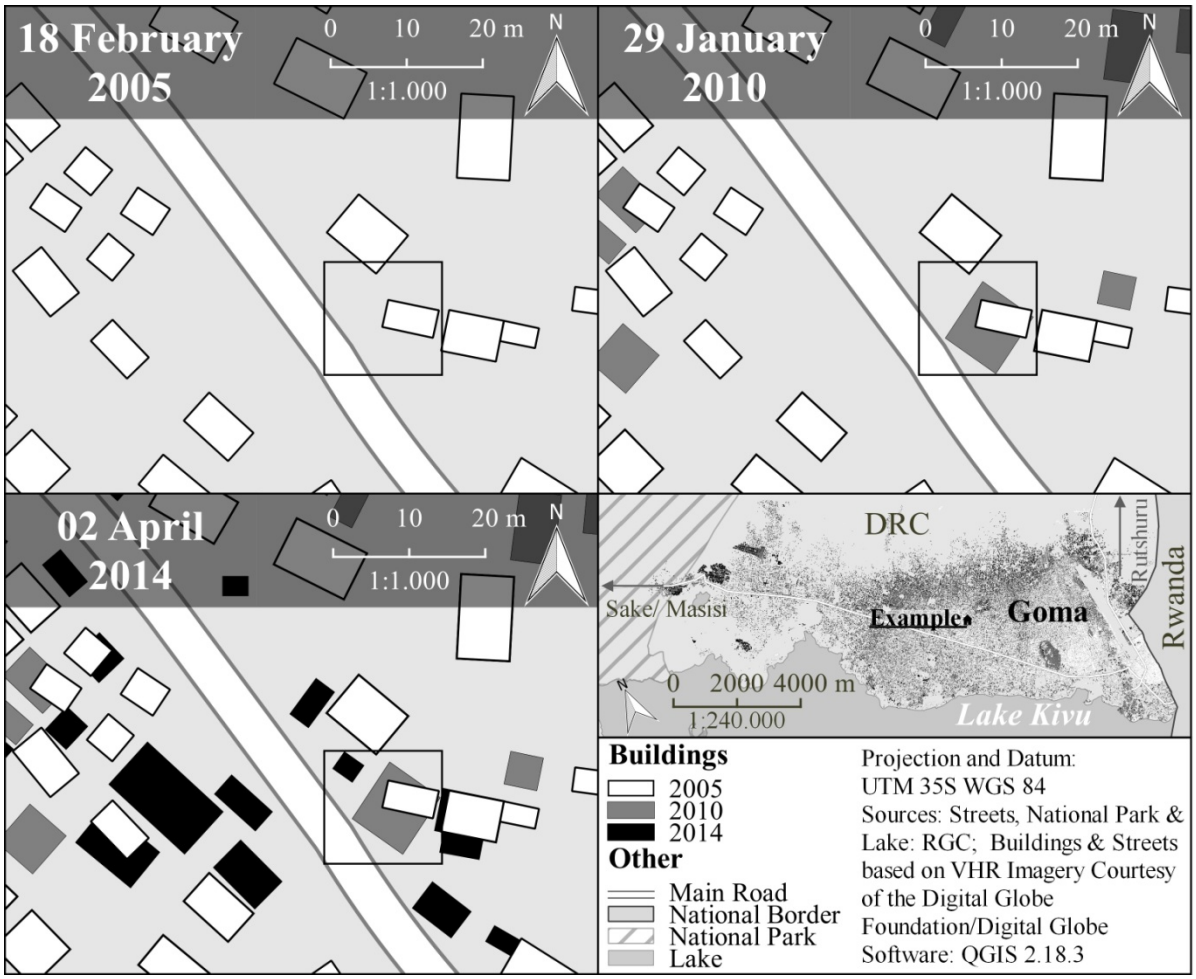


Figure III-6. Example of House Development of a (Long-Term) Displaced Family in Ndosho Neighborhood

One homeowner[29] moved from Burundi to the DRC during the 1990s because of the Burundian civil war. She first settled in Beni (a town in the north) before moving to Goma for security and employment reasons – two reasons typically cited not only in existing literature and reports but also in our interviews. Like 20,000–40,000 other Goméens,[30] she lost her house in the center of Goma in the 2002 volcanic eruption. Homeless and with four children, she initially lived with friends. She then took out a loan to buy a parcel of land in

[29] Interview with A HOMEOWNER AND HER FAMILY IN NDOSHO 2016. Interview # 46, in Ndosho. *In:* PECH, L. (ed.).

[30] Official numbers vary: 14,000 buildings were destroyed and 350,000 people displaced according to KANENE, C. 2014. Projet d'Appui au Processus d'Elaboration du Plan de Rénovation Stratégique de l'Agglomération de Goma. UN Habitat.. According to BAXTER, P., ALLARD, P., HALBWACHS, M., KOMOROWSKI, J., ANDREW, W. & ANCIA, A. 2003. Human health and vulnerability in the Nyiragongo volcano eruption and humanitarian crisis at Goma, Democratic Republic of Congo. *Acta Vulcanologica,* 14**,** 109. the homes of 120,000 people were destroyed. According to BÜSCHER, K. 2011. *Conflict, state failure and urban transformation in the Eastern Congolese periphery: The case of Goma.* Ghent University. 17,500 households became homeless.

the neighborhood of Ndosho, which has one of the highest rates of posteruption growth[31] and one of the highest shares of IDP housing.[32] She constructed a wooden house. With the money she earns as a domestic worker for an international UN employee, she is able to pay back the loan of USD 6,000 with the expectation of eventually owning a land title. Following the construction of the initial house (upper left map in **Figure III-6**), she took in a relative and her child in 2010 and thus added an extension to the main house as well as a latrine (lower left in **Figure III-6**). In many aspects, this pattern is typical for IDPs living in Goma, which is the final destination for many following multiple displacements.[33] Also for other cases discussed in the literature, more permanent conflict induced migration to cities seems to be a general tendency, as the conflicts may be reinforcing the attraction of urban areas that has been observed elsewhere in Africa, and cities offer opportunities not available in less networked settings (Bakewell and Bonfiglio, 2013, Raeymaekers, 2011). Hosting IDPs appears to be a general custom throughout the Kivu provinces. Many of our Goméen interviewees reported that they had hosted an IDP at least once. And as in the homeowner's story, people have to find the economic means to support this addition to their family, such as with the UN or NGOs. The humanitarian industry shapes Goma's urban profile not only by intervening and providing employment opportunities but also by spatially transforming Goma's cityscape. This will be discussed in the next section.

Humanitarian Urbanism: The Reproduction of the Colonial "Dual City"

The presence of international donor and humanitarian agencies in Goma, which turned the city into an "NGO hotspot," is a direct consequence of its central position in DRC's ongoing armed conflict (Büscher and Vlassenroot, 2010) and its lack of basic public services due to gradual state withdrawal. The arrival of humanitarian NGOs and UN agencies started during the Masisi conflicts in the early 1990s and continued after the Rwandan genocide of 1994.

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[31] Interview with AN EMPLOYEE OF UN HABITAT KINSHASA 2016a. Interview # 6, UN Habitat Kinshasa *In:* PECH, L. (ed.) *UN Habitat.*

[32] KAMBALE MAKUTANO, S. 2016. *Goma: Problème de Croissance d'une Ville Tropicale aux Pieds du Volcan Nyiragongo (RDC).* Master Master, Institut Superieur d'Architecture et d'Urbanisme (ISAU), Kinshasa. and interview with A MASTER'S STUDENT FROM GOMA AT ISAU 2016. Interview # 32, Institut Superieur d'Architecture et d'Urbanisme (ISAU). *In:* PECH, L. (ed.) *Titres Fonciers, Planification Urbaine et Développement Urbain - Goma.*

[33] KAMBALE MAKUTANO, S. 2016. *Goma: Problème de Croissance d'une Ville Tropicale aux Pieds du Volcan Nyiragongo (RDC).* Master Master, Institut Superieur d'Architecture et d'Urbanisme (ISAU), Kinshasa. and interview with A MASTER'S STUDENT FROM GOMA AT ISAU 2016. Interview # 32, Institut Superieur d'Architecture et d'Urbanisme (ISAU). *In:* PECH, L. (ed.) *Titres Fonciers, Planification Urbaine et Développement Urbain - Goma.*

During the Second Congo War (1998–2003), social services were almost entirely provided by international aid organizations. This was because the rebel movement in control of Goma at the time, the Rassemblement Congolais pour la Démocratie-Goma (RCD-G), did not engage in public social services (Büscher, 2011). Due to the 2002 eruption of Mount Nyiragongo and the incapacity of the RCD leadership and central government in Kinshasa to provide emergency relief,[34] the number of humanitarian agencies in Goma totaled about 200 after the volcanic eruption – comparable to the number of agencies present after 1994 in the aftermath of the Rwandan Civil War (Oldenburg, 2015).[35] The post-2006 intensification of violence prompted the number of international NGOs in Goma to double between 2006 and 2008 (Büscher and Vlassenroot, 2010).

As with other "aid towns" which evolve into sites of a vast humanitarian industry in war-torn regions, we can study Goma's process of "humanitarian urbanism" (Potvin, 2013) – a term that refers to the production of urban space through a humanitarian presence. Urbanization patterns in Juba (South Sudan) and Gulu (northern Uganda) have been equally analyzed in the literature within this conceptual framework, revealing interesting parallels with our case (Büscher et al., 2018, Newhouse, 2017, Branch, 2013). International NGOs play a big role in shaping Goma's cityscape due to their collective impact on the urban economy, politics, and the built environment. Despite their offices and residences being concentrated along the lakeshore in the city center and further westwards,[36] the spatial configuration and maintenance of Goma's dual cityscape cannot be exclusively attributed to the process of humanitarian urbanism. Most of the prestigious residences are built on remnants of colonial infrastructure and ground plots and are owned by local elites – many of which are rented out to international staff. Parts of this elite already emerged during the Mobutu period in the 1980's, owning much of the land along the lakeshore. Others emerged as "big men" during the boom in the coltan and cassiterite trades and reinvested their money in real estate and other lucrative urban businesses. These neighborhoods are characterized by a low building density that appears to be stable over time. New construction works took

[34] Interview with AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise.*
[35] Interview with ibid.
[36] Interviews with an inhabitant of Himbi, Goma (2016); an inhabitant of Les Volcans, Goma (2016), and own observations.

place on plots that were empty due to the destruction caused by the volcanic eruption in 2002. Satellite imagery reveals spacious sites (**Figure III-7**, left) with detached houses and large gardens. Another feature is that, with the exception of one 120 m long strip (**Figure III-7**, right), the entire lakeshore is privatized and covered with luxurious residences. Gomeéns use this strip, locally referred to as the "public beach" to get water from the lake as the city's lack of sanitary infrastructure deprives most of the neighborhoods of an affordable water supply.[37] This strip of lakeshore is currently undergoing construction arranged by the German Development Cooperation.[38]

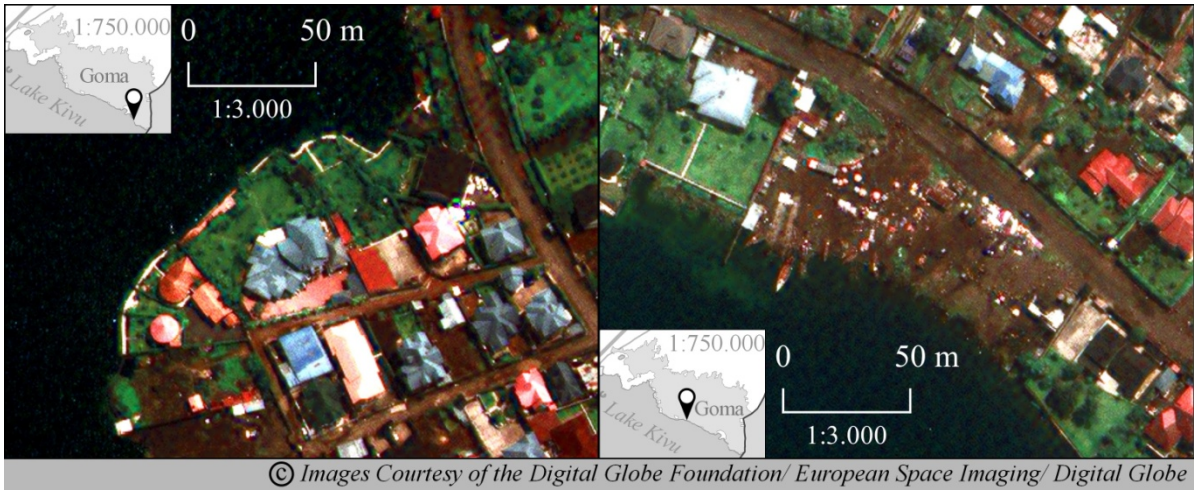

Figure III-7. Private Homes along the Lakeshore (Left); Goma's "Public Beach" (Right)

Himbi and Les Volcans constitute the wealthiest parts of the city (Büscher, 2011, p.98). Inhabitants consist of international NGO and UN agency staff, local businessmen, high-ranking politicians, military staff, and other urban elites. Oldenburg (2015, p.319) remarks that "parcels of land on the shores of Lake Kivu have become luxury enclaves for humanitarian workers. Their headquarters and residences are adjacent to old patrons and new elites, most of the latter making a fortune out of war while excluding 'ordinary people' from free access to the lake and resulting in sociospatial hierarchies." Many of these plots of land belonged to former president Mobutu, who distributed them in the 1970s and 1980s to political elites as part of his patron-client system of rule (Büscher, 2011, pp. 63). The choice of international NGOs and UN agencies to set up in these neighborhoods can be explained

[37] Interview with AN EMPLOYEE OF DEUTSCHE WELTHUNGERHILFE 2016. Interview # 22, Deutsche Welthungerhilfe (German development Cooperation). *In:* PECH, L. (ed.). and own observation.
[38] Interview with AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.* and own observation.

by the presence of infrastructure, such as paved roads, electricity, and sanitation.[39] The installation of luxurious offices and apartment buildings in the better-equipped neighborhoods has intensified the socioeconomic inequalities between these and the remaining neighborhoods.[40] Although this discrepancy originally stems from the colonial dual-city structure, it has been strongly reproduced by dynamics of humanitarian urbanism.

Militarization of the Cityscape

A long history of war resulted in the profound militarization of governance, state-society relations, and society in general in eastern DRC (Verweijen, 2016). On the city level, it has strongly influenced political life, economic networks, urban governance, and daily urban life in Goma (Büscher, 2011, Oldenburg, 2012). This militarization can also be detected in the changing cityscape, as public space has been transformed into military barracks or UN compounds (Büscher, 2016). In the literature this process is sometimes referred to as the transformation of urban "warscapes," referred to by Hoffman (2007) as the "city of barracks."

The case of the Katindo military camp[41] (**Figure III-8**) and its remarkable development will shed more light on how the militarization of public space is taking shape at the local level and involves several actors. Located in Kasika, close to Goma's center, the camp hosts the 5th Brigade of the FARDC, police personnel, and their families.[42] As the main military base in Goma, its dilapidated infrastructure and hospital, total lack of military facilities, and dense concentration of informal shacks very well represent the current image of the Congolese security forces. Moreover, the fact that it has been occupied by rebel forces throughout the tumultuous episodes of conflict reinforces its symbolism of FARDC "failure." Goma's

[39] AN EMPLOYEE OF AN INTERNATIONAL NGO 2016. Interview # 36, Informal background talk. *In:* PECH, L. (ed.), ibid., AN EMPLOYEE OF UN OCHA KINSHASA 2016c. Interview # 11, UN OCHA headquarters. *In:* PECH, L. (ed.) *UN OCHA.*

[40] KANENE, C. 2014. Projet d'Appui au Processus d'Elaboration du Plan de Rénovation Stratégique de l'Agglomération de Goma. UN Habitat.; Interview with a A MASTER'S STUDENT FROM GOMA AT ISAU 2016. Interview # 32, Institut Superieur d'Architecture et d'Urbanisme (ISAU). *In:* PECH, L. (ed.) *Titres Fonciers, Planification Urbaine et Développement Urbain - Goma.*

[41] As access to the military camp is greatly restricted, the visit was carried out with the Congolese Red Cross.

[42] Interviews with AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma*, AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise.*

inhabitants refer to the camp and its surroundings as a place of disorder to be avoided after sunset.[43]

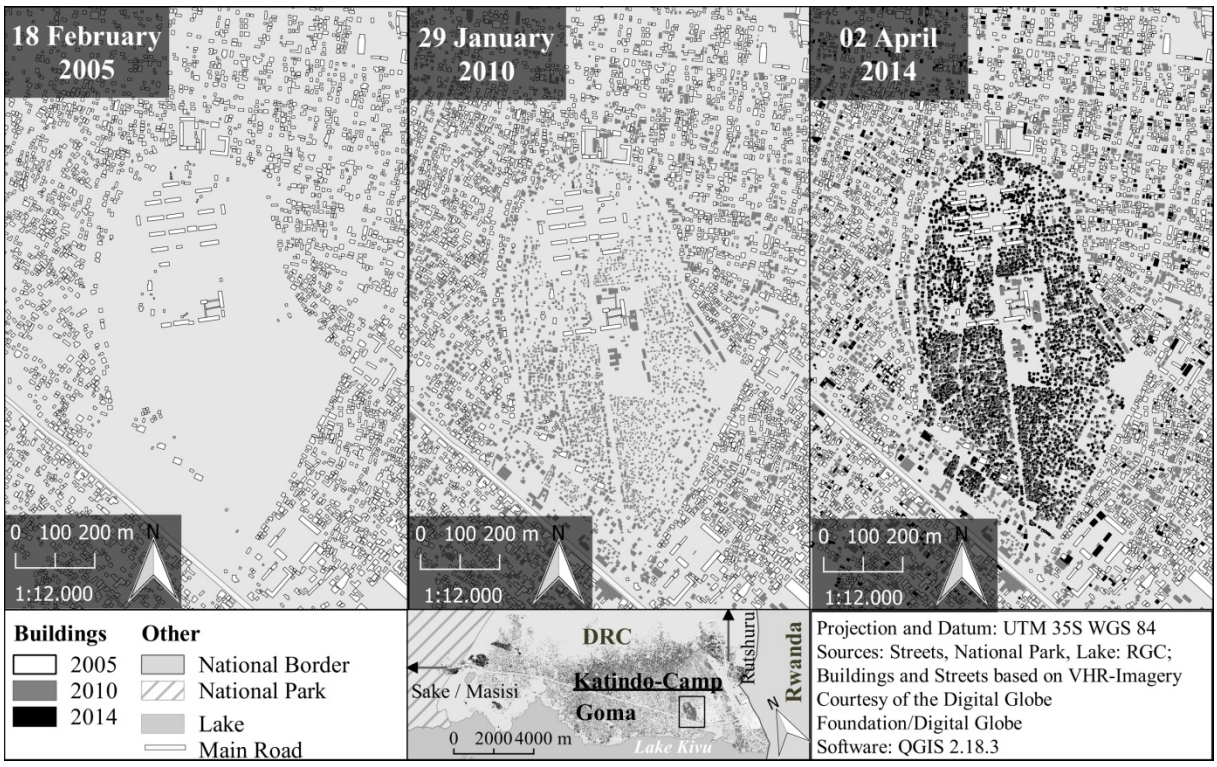

Figure III-8. Military-Family Huts at Katindo Military Camp in Kasika Neighborhood, 2005, 2010, and 2014

The Katindo military camp dates back to the Mobutu era, during which it marked Goma's outskirts. After the end of the Rwandan Civil War, it temporarily hosted Rwandan military members who had fled their country (Dupaquier and Mugenzi, 2010, pp. 317–-318). Congolese troops were deployed to Goma at the start of the Second Congo War (1998–2003) in order to stem the threat of the RCD.[44] Military families remained in the camp, while FARDC soldiers were deployed to the fronts. Once the RCD took control of Goma, the camp became a rebel base. In 2012 another short-lived episode of rebel control occurred when M23 rebels briefly took over the city.

As **Figure III-8** shows, the space was almost empty in 2005, with the exception of some barracks. In 2005, between the RCD and CNDP rebellions, huts started to appear apparently

[43] Own observations and informal talks with urban inhabitants.
[44] Interview with AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*. . For more information on the RCD rebellion, see Tull 2003.

as the result of an accord to subdivide the camp's margins into parcels[45] (Tshala, 2005). This not only prompted military members to bring (more of) their family members, it also attracted civilians with no links to the military.[46] Huts proliferated inside the camp as the families of new soldiers arrived and the families of fallen soldiers remained. Officially, army widows and children were required to leave military installations;[47] however, as the state is unable to financially provide for army members and their families, it turns a blind eye. Furthermore, soldiers whom the state was unable to compensate with pensions also stayed. Grown-up children of military families often remained in the camp and started their own families. As such, a large informal occupation took place and the proposed official parceling scheme was never implemented. From time to time, there have been mass expulsions of people who could not prove their affiliation to a military member. However, just as in IDP camps, those expelled simply returned later.[48] The Katindo military camp provides refuge not only to army widows and their children but also to stigmatized women who have experienced sexual violence (Liebling et al., 2012). Other inhabitants include street children, the elderly, and disabled persons. In many respects, the camp became a shelter to those segments of the population that were affected by the dynamics of war and crisis and had nowhere else to go. The building materials and the density of the huts mean Katindo resembles a slum or an IDP camp more than it does a military installation.[49] As the city grew around it, the camp eventually became a part of Goma's urban tissue. Because of overcrowding, parts of the camp were closed down in 2014, and soldiers and military police members were relocated to a base at Rumangabo, about 35 km away from Goma. Nevertheless, Katindo remains the main military camp in Goma.

MONUSCO, the biggest peacekeeping mission in UN history, is another important actor that has contributed to the militarization of Goma's cityscape. Starting with the deployment of military observers in Goma in 1999, this mission has deployed an increasing number of

[45] Interview with ibid.
[46] Interviews with AN EMPLOYEE OF DEUTSCHE WELTHUNGERHILFE 2016. Interview # 22, Deutsche Welthungerhilfe (German development Cooperation). *In:* PECH, L. (ed.), AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*
[47] Interview with AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*
[48] Interviews with ibid., AN INHABITANT OF KASIKA - GOMA 2016. Interview # 39, informal background talk in Kasika. *In:* PECH, L. (ed.).
[49] Own observations

military and civilian personnel to the city. In 2014 MONUSCO set up its eastern headquarters in Goma (Secretary-General of the United Nations, 2014), maintaining a strong presence in the city's urban public space with patrols, tanks, and trucks. Between 2005 and 2014, eight new facilities – including office buildings, compounds, a hospital, and a tea factory – were constructed by and for the peacekeeping mission.[50] At present, MONUSCO occupies a total of 15 facilities covering 23 hectares.

New MONUSCO buildings have been constructed primarily in attractive areas with good access to roads, water, and electricity networks (**Figure III-9**).[51] In July 2016 MONUSCO began construction of the new logistics base for North Kivu in a 10-hectare parcel owned by the Regié des Voies Aériennes (Congolese Air Traffic Control, RVA) – one of the last undeveloped areas in the city center. The base will include warehouse facilities, workshops, administrative buildings, and a level 3 hospital.[52]

[50] Interview with AN EX-EMPLOYEE OF MONUSCO 2016. Interview # 23, ex-employee of MONUSCO (Mission de l'Organisation des Nations Unies en République Démocratique du Congo) in Goma. *In:* PECH, L. (ed.).
[51] Interviews with AN INHABITANT OF GOMA 2016. Interview # 13, several interviews with the same interviewee. *In:* PECH, L. (ed.), AN EX-EMPLOYEE OF MONUSCO 2016. Interview # 23, ex-employee of MONUSCO (Mission de l'Organisation des Nations Unies en République Démocratique du Congo) in Goma. *In:* PECH, L. (ed.).
[52] Interview with AN EMPLOYEE OF MONUSCO 2017. Interview # 54, at the MONUSCO logistics base.

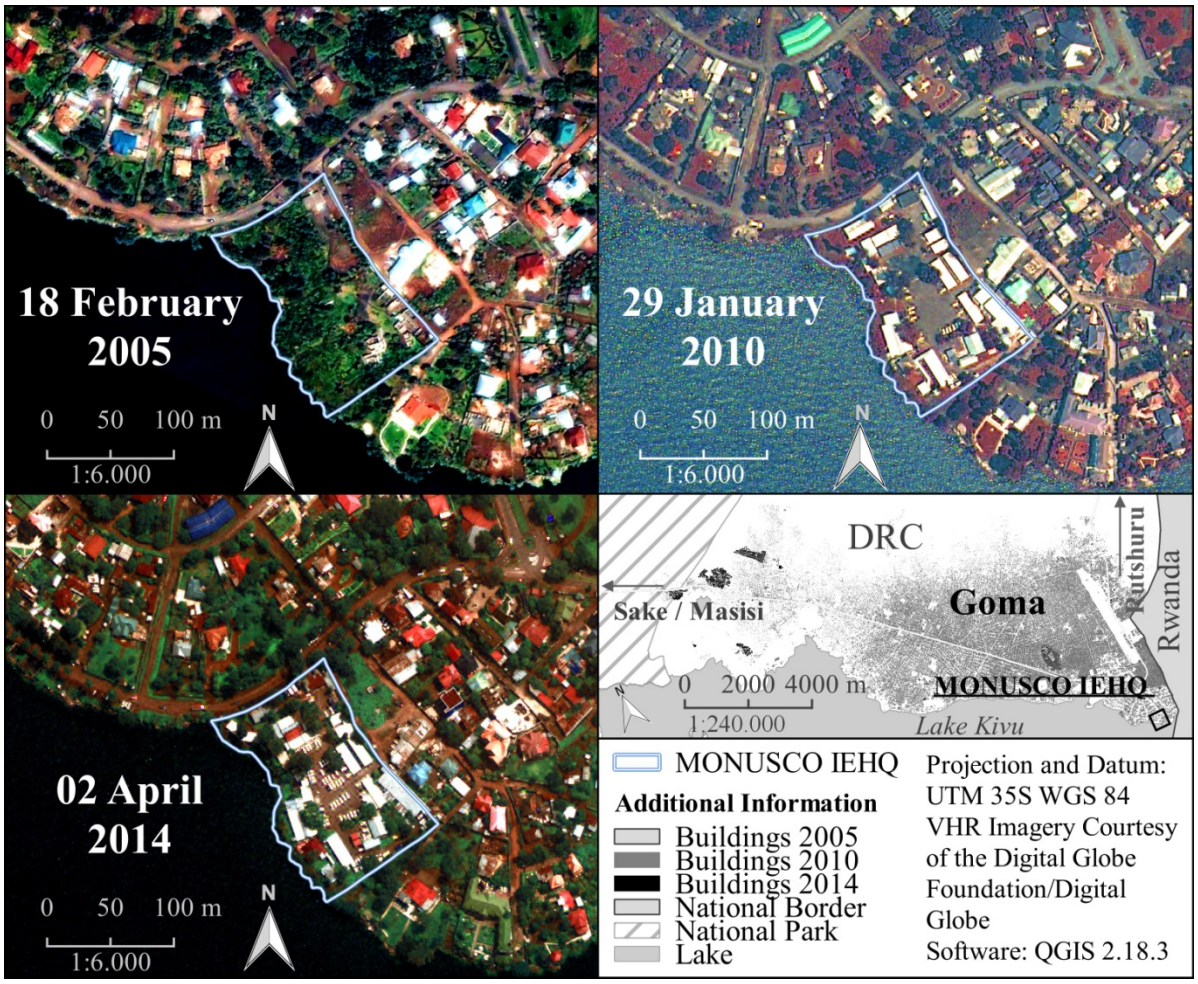

Figure III-9. MONUSCO Eastern Headquarters in Les Volcans Neighborhood, Close to the Rwandan Border

Church-Based Social Action: The Case of the Don Bosco Center

The number of churches in the DRC has increased substantially since the First Congo War in 1996. Nevertheless, it is important to distinguish between traditional Catholic and Protestant churches and the Pentecostal or "born-again" churches that mushroomed in the DRC as a result of poverty and insecurity (Verhoeve et al., 2004). Since colonial times, traditional churches have been important actors in urban development, constructing schools, hospitals, orphanages, and social centers[53] (Verhoeve et al., 2004, de Saint Moulin, 2010). With the weakening of the state set in motion following the Mobutu regime and the state's

[53] Interview with AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise.*

withdrawal from delivering public services, churches and other civil society institutions took over large parts of the provision of public services. In 1998, when the formal state apparatus had largely collapsed, churches operated an estimated 80 percent of the schools in North Kivu (Tull, 2003). Churches have always positioned themselves as providing assistance to the most vulnerable, such as orphans and disabled people (Kahongya Bwiruka, 2016). In the context of state crisis and war the vulnerable population grew to include victims of sexual abuse, IDPs, and war casualties.

In this section we examine the Don Bosco Center founded in 1988 by the Catholic Salesian Order, to investigate the Catholic Church's role in providing urban social infrastructure. The center is situated north of Goma in the village of Ngangi. Although it administratively belongs to the territory of Nyiragongo, Ngangi has been overwhelmed by Goma's growth and is now a de facto part of the city. This case caught our attention as it stands out from its organically shaped urban environment as a very geometrically aligned site.

Having initially started by running a literacy project, today the Don Bosco Center offers facilities for apprenticeships as well as an elementary and a secondary school. The center provides shelter to street children, survivors of sexual violence, former child soldiers, and Goma's inhabitants whenever fighting occurs in the area.[54] The center took in displaced children – especially from the Masisi, Rutshuru, and Walikale territories of North Kivu during the interethnic violence in the early 1990s (Kahongya Bwiruka, 2016) – and also offered refuge to fleeing Rwandans during and after the Rwandan civil war.[55]

[54] Interview with AN INHABITANT OF GOMA 2016. Interview # 13, several interviews with the same interviewee. *In:* PECH, L. (ed.).
[55] Interview with AN EMPLOYEE AT THE DON BOSCO CENTER 2016. Interview # 35, Interview at and walk through Don Bosco Center. *In:* PECH, L. (ed.).

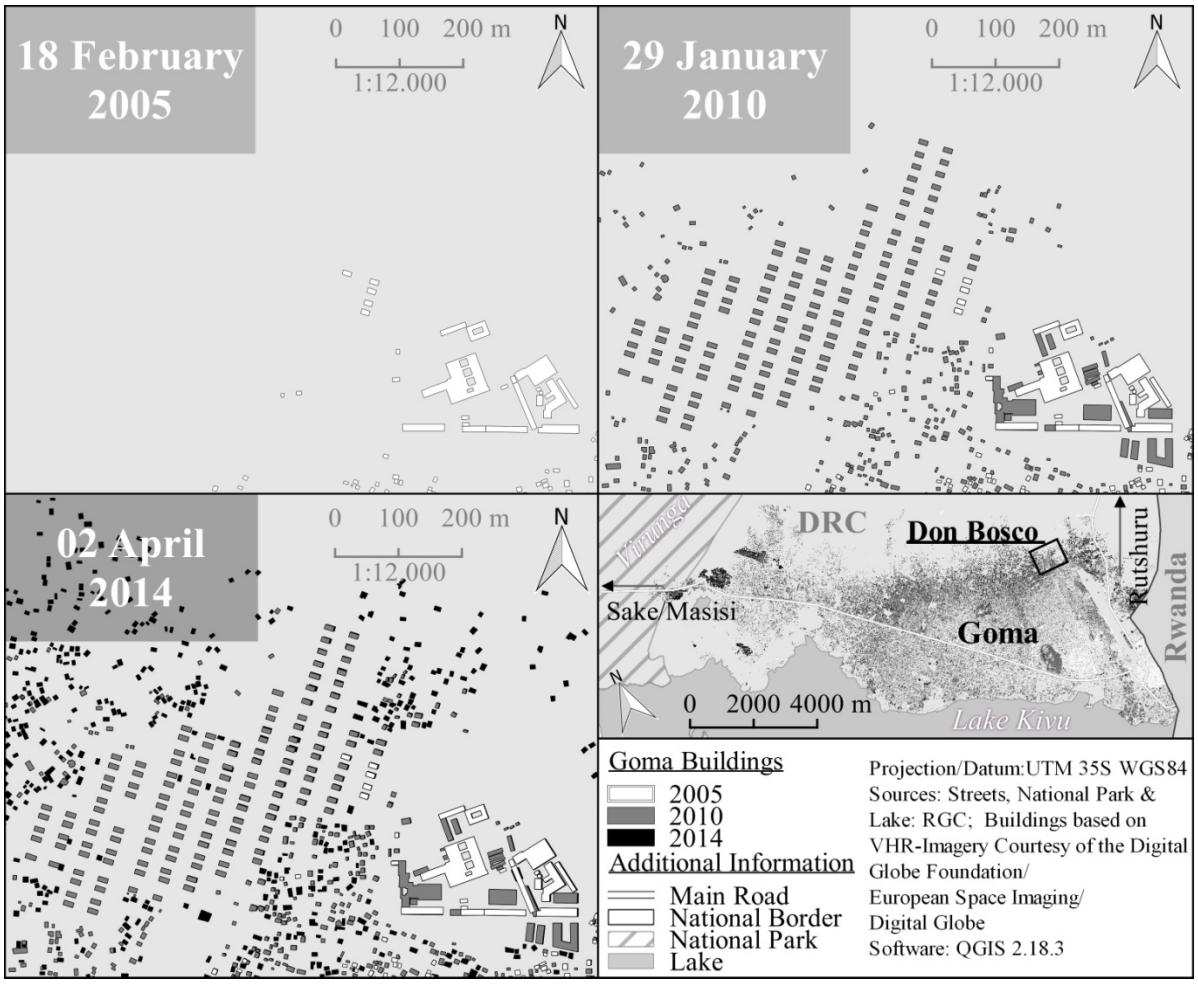

Figure III-10. Don Bosco Center (Lower Right of Each Panel) and Housing Project

In 2005 a social-housing complex was built on the initiative of the Don Bosco Order, consisting of 150 semidetached houses measuring 5 m x 10 m each. The houses contain two bedrooms, a cooking place, a latrine, and a small garden delimited by lava-stone walls. In collaboration with the University of Napoli and Italian Engineers without Borders,[56] a suitability analysis was carried out to take into account a future volcanic eruption (Di Martino et al., 2007). The idea was to provide houses primarily to children who had either lost their homes due to the volcanic eruption of 2002 or forced displacement. However, children were required to live with an adult guardian.[57] Inhabitants could buy their house by

[56] Interview with AN EMPLOYEE AND A VOLUNTEER AT THE DON BOSCO CENTER 2017. Interview # 49, Interview at Don Bosco Center Ngangi. *In:* PECH, L. & SCHUH, P. (eds.).
[57] Interview with AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise.*

repaying a monthly loan of USD 6 over 10 years, representing 10 per cent of the real cost; the vast share was subsidized by the Don Bosco Order and contributions from international donors. Inhabitants unable to pay their share were given the possibility to help with the construction or work at the Don Bosco Center itself.[58] Land titles were granted to the inhabitants once they had fully paid their shares.[59] This nonstate intervention in the urban social environment is beautifully reflected by the geometric characteristics of this complex, which strikingly contrast with its organically developed environment.

5 Conclusion: A Dual Perspective to Understand Urban Spatial Transformations in a Context of Violent Conflict

After more than 20 years of development in the context of a complicated civil war, the spatial effects of violence, displacement, and humanitarian crises are highly visible in Goma's urban landscape. While these effects have been investigated in the field by other researchers, we have added a "view from above," locating and visualizing the spatial impact. This visualization confirms Goma's rapid and dynamic growth, renders it quantifiable, and reveals the (i) repercussions of migration due to insecurity, (ii) spatial consequences of the decade-long presence of international agencies, (iii) militarization of the cityscape, and (iv) impact of church-based social action. While Peyton (2018a) and Van Overbeek and Tamás (2018), for example, analyze the impact of conflict-induced urbanization and land governance in the cities of Goma, Bukavu, and Beni, our analysis offers a deeper spatial engagement with the socioeconomic and political processes described in their work, particularly focusing on the materialities of the changing cityscape.

Furthermore, satellite images taken at different points in time enable us to look back into the past. Where others have reconstructed Goma's atypical history based on the individual life stories of various urban actors (Trefon and Kabuyaya, 2016, Oldenburg, 2012), we have reconstructed the city's history via the individual trajectories of buildings and settlement structures. By examining the temporal trajectories of particular spatial "anomalies" through

[58] Interview with AN EMPLOYEE AT THE DON BOSCO CENTER 2016. Interview # 35, Interview at and walk through Don Bosco Center. *In:* PECH, L. (ed.).
[59] Interview with AN EMPLOYEE AND A VOLUNTEER AT THE DON BOSCO CENTER 2017. Interview # 49, Interview at Don Bosco Center Ngangi. *In:* PECH, L. & SCHUH, P. (eds.).

fieldwork, we learned about the actors behind these trends and were also able to grasp the complexities and sometimes the contradictions in these trajectories, which are evidenced by the transformation of Goma's public space into military camps (and back).

Throughout our analysis, it became clear that Goma's built cityscape is the outcome of broader trends associated with both armed conflict and a weakened state and of highly localized interactions and motives. Therefore, this article demonstrates the importance of a dual perspective in interpreting the different layers of urban landscapes.

To this end, we emphasize the utility of freely available VHR satellite imagery (e.g., from ESA's Sentinel missions) and the growing availability of qualitative data in the Global South. We end this article with a strong plea to researchers to embrace this interdisciplinary approach in order to make sense of urban reconfigurations in contexts of conflict. Analyzing quantitative and qualitative data in relation to academic insights from geography, anthropology, and political science enables us to simultaneously interpret landscapes from above and from below, thus making the invisible visible.

Central Goma and Gisenyi (2014)

Chapter IV:

Armed Conflict and Cross-Border Asymmetries in Urban Development: A Contextualized Spatial Analysis of Goma, Democratic Republic of the Congo and Gisenyi, Rwanda

(submitted, Land Use Policy)

Lisa Pech, Christian Levers, Karen Büscher, Blake Byron Walker

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Abstract

Armed conflicts often cause significant structural disturbances and modifications to urban areas, manifesting as changes to the built environment, namely its extent and the number, density, and configuration of buildings. The geography, magnitude, and impacts of conflict-induced displacement and migration are dependent upon a range of social, political, and geographical factors specific to each respective conflict-episode, resulting in between-state variability in conflict-induced urban growth. Border cities provide a valuable setting to compare these variations, as they share geographical and cultural similarities. This study examines the effects of armed inter- and intra-state conflict on urban spatial development both within and across national borders, focusing on the proximal cities of Goma, Democratic Republic of the Congo (DRC) and Gisenyi, Rwanda, between 1989 and 2014. We conducted a visual analysis of high to medium resolution satellite imagery to map urban spatial development (both urban extent and individual buildings) for both cities. Based on this interpreted imagery, we conducted site visits and interviews in both cities and identified underlying drivers of their development pathways, focusing on the effects of different phases of armed conflict, how their repercussions were governed (or not), and the interdependencies between the two cities. Our analysis revealed remarkable differences in spatial development and urban morphology. While Goma's urban area expands and densifies, Gisenyi's spatial extent remains relatively stable. Stakeholders on the ground identified (intertwined) armed conflict, linked population flows, as well as differences in handling conflict-repercussions between the states as underlying drivers of the observed spatial changes. This study thus provides detailed evidence on the processes and drivers implicit in urban development and change in cross-border cities, their similarities, differences, and interdependencies, with a particular focus on armed conflicts' domestic and cross-border effects.

1 Introduction

Africa is known as the continent with the highest rates of urban growth in the world. The recent development of urbanization in Sub-Saharan Africa is, however, controversial as the data used to analyze urbanization tendencies rely on censuses, which in most of the cases date back several decades (Nielsen and D'haen, 2015). The effects of (rapid) urbanization in Sub-Saharan Africa are important to study, and two central positions have been adopted toward the interrelated dynamics of rapid urban growth fueled by in-migration: on the one hand, urban growth brings along economic benefits through the agglomeration of economies and innovation, on the other hand, rapid urbanization is not backed by local investment and stable economic growth (Potts, 2012). Furthermore, urban infrastructure is not being constructed at the same pace as the cities grow, which creates educational, security, sanitary, environmental and transportation problems. While social, economic, and political aspects of urban development[60] in Africa have been extensively studied (e.g., Murray and Myers, 2007, Simone, 2001, Myers, 2011, Pieterse, 2011), a particular subsection of recent studies scrutinizes urban topics in conflict and post-conflict scenarios. Studies of Sub-Saharan African cities in conflict areas investigate the interlinkage between state decline and conflict, track displacement patterns, and scrutinize urban socio-economic transformations, or portray how living conditions deteriorate due to armed conflict (Omasombo, 2005, Verhoeve et al., 2004, Büscher, 2011). However, explicitly spatial analyses of armed conflict as a driver of urbanization in Sub-Sahara Africa are, to date, rather scarce (Pech et al., 2018, Wilson, 2014). This paucity is particularly notable for border cities in conflict settings. Border cities constitute a unique opportunity for comparative spatial analyses. Even though border regions are spaces where urbanization is picking up speed and scope on a global level (Chen and Stone, 2017), existing (border-city) studies have a narrow regional diversity and dominantly focus on the border region between Mexico and the United States of America (Coplan, 2009). They are also restricted in their thematic focus as they do not investigate violence or armed conflict as a driver of urban development. Most (African) borders drawn during colonial times play central roles in socio-economic life, as they generate cross-border

[60] This article employs the term *urban development* in its broader sense in order to include aspects such as changes in urban land use, urbanization, urban growth, urban expansion, spatial development, and urban change processes.

differences in legal frameworks and economic regimes (Jackson, 2006). Thriving on these differences, a notable physical effect is the emergence of border (boom) towns: strategic nodes in international economic networks (Dobler, 2009) that are (inter)nationally connected (Nugent, 2012), despite often being located far from the national capital (Jackson, 2006). In the presence of armed conflict, border towns become central hubs for political, military, and humanitarian engagement, and feature flows and settlements of displaced persons (Wilson, 2014). Furthermore, they can become the foci of profitable business activities, the commerce of foodstuffs and other essential supplies, trade in natural resources, and real estate speculation, stoked by the presence of well salaried international personnel and national elites (Peyton, 2018a). Strong economic opportunities constitute a major pull-factor for border cities, and rural-to-urban migration is observable all across Africa. Nevertheless, economic pull-factors differ between conflict-settings and peaceful areas. Relatively secure urban zones gain attractiveness in zones marked by decades of inter- and intrastate war (Wilson, 2014). This confluence of factors is regarded as one of the primary causes of urban growth along the Congolese-Rwandan border (Soi and Nugent, 2017). Detailed and spatially explicit cross-border research on the resulting urban expansion is necessary to further elucidate these spatial dynamics in conflict zones, a gap that this paper seeks to address.

Few studies have examined urban agglomerations divided by a national border; the notable few that have done so have used long-term qualitative field research or remote sensing. Qualitative field research from various academic disciplines has investigated African borderlands and twin-city constellations for state regulation practices at the border (South Sudan/Uganda, DRC/Rwanda) (Hollstegge and Doevenspeck, 2017), (in)formal trade and economic networks (DRC/Rwanda/Uganda) (Doevenspeck and Nene, 2012, Raeymaekers, 2009, Lamarque, 2014), (economic) opportunities for different actors in displacement sites along a border (Chad/Sudan) (Behrends, 2014), or identity formation and transnationalism (DRC/Rwanda) (Mathys, 2014). These studies suggest that the growth of towns along national borders in conflict zones is partially explained by the influx of internally displaced persons and refugees. They furthermore find that conflict can contribute to a decline of border towns, which then is followed by post-conflict conversion into booming nodes of international trade networks (Büscher, 2011, Dobler, 2009, Soi and Nugent, 2017). However, a strong increase in efforts and complications has prevented researchers from completing field-based studies of cross-border conflict zones in an equal way (e.g., paperwork/visas, language, contact persons), most notably in cases of ongoing hostilities between neighboring states. Furthermore, the quality, comprehensiveness, and comparability of official data are

unlikely to be collected through the same methods, making comparison difficult. Conversely, border-city research from the domain of remote sensing has equally measured spatial city growth, with the benefit of (impartially) inferring changes on the ground from widely available satellite imagery, across political borders. For example, a recent study examined urban change and growth in paired cities between Mexico and the USA, finding unequal patterns and rates of growth of built-up area between the two sides of the border despite comparable population growth (Zhao et al., 2017). Another study focusing on cities along the U.S.-Canadian border, which combined medium-resolution satellite imagery with census data and building-permit records, also found that an increase of urban residents and growth of impervious surface did not coincide: Vancouver's (Canada) two million urban residents occupy far less land and reside in consistently compact neighborhoods compared to their counterparts in the Puget Sound region (USA) who occupy much more space per inhabitant (Davis and Schaub, 2005). These studies confirm the utility and validity of remote-sensing methods for exploring and quantifying urban growth. Yet, there is no analysis of border cities that combines remote-sensing techniques and in-depth field interviews to investigate urban development in border towns during armed conflict and forced displacement.

While both qualitative field-research and remote sensing methodologies have provided significant contributions to understanding cross-border urban dynamics, they each entail shortcomings that hinder holistic assessments of urban development: long-term field research often favors qualitative descriptions over quantitative and spatially detailed information, and remote sensing lacks contextual information and local knowledge (Pech and Lakes, 2017). We argue that the confluence of armed conflict, (cross-border) forced displacement, and urban growth constitutes an important research nexus for the detailed elucidation of drivers of urban development.

This study scrutinizes the spatial development of the adjacent border-cities Goma, in the Democratic Republic of the Congo (DRC), and Gisenyi, Rwanda, which have been engaged in inter- and intra-state war for decades that has led to incongruent political regimes. We used a combined approach presented in earlier publications (Pech and Lakes, 2017, Pech et al., 2018). Based on the visual interpretation of very high to moderate resolution satellite imagery, we mapped, quantified, and analyzed spatial patterns of urban development for both cities between 1989 and 2014. Subsequently, field visits and interviews were conducted in Goma and Gisenyi to obtain narratives and identify underlying drivers for observed urbanization trends. In particular, we compared the spatial development of Goma and Gisenyi in order to identify commonalities and differences in their urban development and

the underlying drivers for these commonalities and differences. We furthermore developed a simplified framework of factors affecting urban development in the study area.

2 Methodology and Data

2.1 Research Area: The Cities of Goma and Gisenyi

Goma and its Rwandan neighbor Gisenyi, located at the center of almost thirty years of armed inter- and intrastate conflict[61], are situated within the western branch of the East African Rift Valley and share the physical-geographic setting between two active volcanoes and Lake Kivu. Different conflict episodes, a volcanic eruption in 2002 that affected mostly Goma, and changes in political regimes affected both cities' development. Established as colonial border posts in 1905 (Gisenyi) and 1906 (Goma) between Ruanda-Urundi (Germany) and Congo Free State (Belgium), both cities were and are located between different colonial and post-colonial regimes, with the porosity of the border depending on the relationship between them (Soi and Nugent, 2017, Mathys, 2014, Jackson, 2006, Doevenspeck, 2011). Germany lost Ruanda-Urundi to Belgium in World War I, and during (Belgian) colonial times, Goma's importance derived largely from its role as a hub in directing Rwandan laborers across the border (Soi and Nugent, 2017). In 1930, an urban plan was designed for Goma, including an airstrip, today Goma's International Airport. The urban plan has never been officially updated, despite the city's tenfold increase in area[62]. Congo became independent from Belgium in 1960, followed two years later by Rwanda.

Today, in terms of general economic and political characteristics, the Congolese side of the border displays weak, locally contested state authority, insecurity, negotiable and inconsistent economic regulation, but also greater employment opportunities. The Rwandan side of the border is characterized by strong, centralized political authority, (physical)

[61] The Rwandan civil war and genocide (1990 – 1994), the two great Congo Wars (1996-1997 and 1998 – 2003), the Kivu conflict (2006 – 2009) and its aftermath, and the so called period of 'violent peace'BERWOUTS, K. 2017. *Congo's violent Peace; Conflict and struggle since the Great African War,* Chicago, University of Chicago Press. that affects the region until today.

[62] Interview with A PROFESSOR AT ISAU KINSHASA 2016. Interview # 20, Institut Superieur d'Architecture et d'Urbanisme (ISAU). *In:* PECH, L. (ed.).

security, heavy social and economic regulation and a relative lack of employment prospects (Peyton et al., 2019).

Since 1988, Goma is the provincial capital of North Kivu, a region that has suffered exceptionally from violence. Urban centers in Congo's east often embody comparatively 'safe' spaces for internally displaced persons (IDPs) or refugees, and are at the same time strongholds for rebel movements, or their strategic targets, as well as economic hubs (Büscher, 2018b, Büscher, 2016). Goma is the center of Congo's 8th military region, housing the army's (FARDC) 5th brigade, and since 2013/14[63] the United Nations (UN) peacekeeping mission's (MONUSCO) eastern headquarters (Secretary-General of the United Nations, 2014).[64] Additionally, Goma counts a large UN agency and (international) NGO presence. The UN Office for the Coordination of Humanitarian Affairs (OCHA) lists more than 270 humanitarian organizations with bases of operation in Goma for 2013 (Peyton, 2018a).

Goma mediates Gisenyi's international access as it represents a node in regional trading networks and international commerce with Africa's East coast and beyond, facilitated through the border location and the presence of a port and international airport (Büscher, 2011, Lamarque, 2014). Goma prospers due to the proximity to several artisanal mining and (illegal) charcoal production sites, and its fertile hinterlands provide agricultural production possibilities, even though this production is strongly affected by the security situation.[65] Approximately 20,000 to 22,000 people per day are engaged in cross-border trade. Minerals are exported to or via Rwanda, and in return, construction materials, petroleum, agricultural products and consumer goods are imported from Rwanda and distributed all over eastern DRC. (Small-scale) trade generates important revenues on both sides of the border, and it furnishes the most visible evidence of the economic interdependence between the cities. Nevertheless, Goma has prospered more from cross-border trade than Gisenyi (Hollstegge

[63] approximately 800 civilian and military 3000 personnel was additionally deployed to Goma and the city of Sake in Goma's vicinity when Goma became the operational hub and the force headquarters in 2013/2014 UN SECURITY COUNCIL 2013. Resolution 2098 (2013)., Interview with AN EMPLOYEE OF MONUSCO 2016. Interview # 5, informal background talk. *In:* PECH, L. (ed.)..

[64] Communication with AN EMPLOYEE OF MONUSCO 2016. Interview # 5, informal background talk. *In:* PECH, L. (ed.).

[65] Interview with AN INHABITANT OF GOMA 2016. Interview # 13, several interviews with the same interviewee. *In:* PECH, L. (ed.)., Interview with A RESEARCHER OF POLE INSTITUTE GOMA 2017. Interview - Cross Border Migration due to Insecurity/Infrastucture/Livelihood Opportunities. *In:* PECH, L. (ed.).

and Doevenspeck, 2017, Tegera et al., 2007, Lange and Kimanuka, 2010). Goma experiences growing real estate speculation, and the city's construction industry provides employment for Congolese and Rwandans (Peyton, 2018a)[66]. Currently, the city expands over 60 km², has eighteen neighborhoods and an estimated 800,000 to 1,500,000 inhabitants (Mairie de Goma, 2016, Kanene, 2014). These estimates are based on samples[67], since the last population *census* in the *DRC* was conducted in 1981, making existing demographic records difficult to rely on (Mairie de Goma, 2015). [68]

Chaotic and vibrant Goma is contrasted by the calm, well-organized, and tidy Gisenyi, which is well equipped with urban infrastructure.[69] Rwanda's security apparatus is tightly organized, since the end of the genocide and crime rates are low[70.] Conversely, Goma's crime rate ranks among the highest in Congo. Gisenyi has been studied significantly less than Goma. The city shares similarities with Goma such as a colonial past and city center and a history of violence. Today, the city differentiates itself from its Congolese counterpart primarily through its smaller area (~11 km²) and population of only 53,603 according to the 2012 census (Government of Rwanda and GGGI, 2015). Gisenyi's inhabitants find regular employment in Gisenyi's financial sector, that benefits from the unstable economy and security and situation in (eastern) DRC (Doevenspeck and Nene, 2012), in educational institutions, or at one of three of Gisenyi's markets. Many of Gisenyi's inhabitants depend on agricultural activities, despite an ambitious modernization program initiated by the Rwandan government (Huggins, 2017).[71] The city has a small tourism sector, with hotels

[66] Interview with AN INHABITANT OF HIMBI/LOCAL CONSTRUCTION ENTREPRENEUR - GOMA 2016. Interview # 41, in Himbi. *In:* PECH, L. (ed.).
[67] Interview with the MAIRE DE GOMA 2017. *In:* PECH, L. (ed.).
[68] This data unreliability or total lack certainly applies for the Congolese side of our research Area, Goma, where conflict and state informalization have severely weakened the administrative apparatus, and therefore services related to demographics, cadastres, and urbanism are being run by bureaucrats who are often unpaid and highly corrupt, which makes obtaining demographic statistics a tough mission DE HERDT, T. & DE SARDAN, J.-P. O. 2015. *Real governance and practical norms in Sub-Saharan Africa: the game of the rules*, Routledge, PECH, L., BÜSCHER, K. & LAKES, T. 2018. Intraurban development in a city under protracted armed conflict: Patterns and actors in Goma, DR Congo. *Political Geography,* 66**,** 98-112.. The introduction of JERVEN, M. 2013. *Poor numbers: how we are misled by African development statistics and what to do about it*, Cornell University Press., describing the situation in Zambia, gives an almost identical description of the Congolese administrative institutions visited during our research stays in the DRC.
[69] Own observations during research (stays between February 2016 and October 2017
[70] Interviews A RESEARCHER OF POLE INSTITUTE GOMA 2017. Interview - Cross Border Migration due to Insecurity/Infrastucture/Livelihood Opportunities. *In:* PECH, L. (ed.), A CONGOLESE PROSECUTOR 2016. Security Situation and Crime Rates/DRC. *In:* PECH, L. (ed.).
71 Interviews with A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.).and AN EMPLOYEE OF THE ONE STOP CENTER OF RUBAVU DISTRICT 2017. Urban Planning and Administrative Structures of Rwanda. *In:* PECH, L. (ed.).

that serve as base camps for visitors of north-western Rwanda, but also as main weekend destinations for Goma's international personnel. Unlike Goma, Gisenyi features a brewery, where beer (a highly-valued local commodity) is produced and exported into Congo. Congolese beer is produced in northern North Kivu and South Kivu, and therefore has to be transported overland through dangerous territories controlled by various armed groups, or across Lake Kivu.[72]

Gisenyi has always been more accessible over land than its Congolese counterpart in terms of distance and transport infrastructure from the capital. It is approximately 150 km west of Kigali, reachable via a continuously tarred and well-lit road,[73] while Goma is located over 1,500 km east of Kinshasa, from where it is only accessible via airplane. These different degrees of physical connectedness between the respective secondary city and its capital reflect how administrative and economic integration differ. While the authority of the Congolese central administration is fragmented and locally contested, and was completely cut off during the Congo Wars (Büscher, 2016, Verhoeve et al., 2004, Vlassenroot and Büscher, 2013), Gisenyi is effectively controlled by the central government, which has direct control over local governments. The Rwandan administrative system is generally held to be one of the most effective in Africa (Huggins, 2017, Lamarque, 2014).

2.2 Spatial Data and Processing Steps

To compensate for the lack of reliable data on population growth and urbanization in the DRC, and the existence of such data for Rwanda only since the beginning/mid-2000s, we used medium-resolution Landsat (30x30 meter) to map the urban extent, Landsat 5 for the years 1989, 1995, and Landsat 7 for 1999. For the years 2005, 2010 and 2014 we used very high-resolution (VHR) satellite imagery (50x50 cm) from three different commercial earth observation satellites to estimate the urban extent, count the number of buildings within the cities' margins, and calculate housing densities. Unfortunately, no VHR data exists for

72 Interviews with several inhabitants of Goma
73 Own observation during several trips between Kigali and Gisenyi/Goma, in 2016 and 2017

previous years. (For detailed information on data processing steps see Pech and Lakes (2017) and Pech et al. (2018)).

Table IV-1: Spatial Data

Data and Source	Properties	Use
Satellite Raster Data		
Quickbird02 Digital Globe	Bands 1–4: 2.4 m, Pan: 0.6 m 2005/02/18 coregistered to WorldView02 (2010), ortho image based on SRTM	Visual interpretation, building extraction, mapping of expansion and densification of built-up area
WorldView02 Digital Globe Foundation	Bands 1–8: 2 m, Pan: 0.5 m 2010/01/29 Mosaic, pan-sharpened, ortho image	
GeoEye01 Digital Globe Foundation	Bands 1–4: 2 m, Pan: 0.5 m 2014/04/02 mosaic, pan-sharpened (0.5 m), ortho image, coregistered to WorldView02 (2010)	
Landsat 5, Landsat 7	Bands 1-5 + 7 (30 m) 1986, 1995, 1999	Visual interpretation, city extents
SRTM DEM NASA	Elevation at 30 m ground sampling distance 2000	Orthorectification of Quickbird02 imagery (2005), cartography
Additional Geodata		
OpenStreetMap vector data (buildings)	2005	Basis vector data for further digitization
Goma topographic map GIS unit MONUSCO	1:11.000 2012	Orientation, identification of neighborhoods
Gisenyi/Rubavu District administrative map, 2016, from: Rubavu One Stop Center (urban planning unit)	1:35,000 2016	Orientation, identification of neighborhoods
Boundaries/ infrastructure Referentiel Geographique Commun (RGC)	2015/2016	Cartography

We manually digitized urban extents based on the Landsat images (and with the help of local knowledge during visits in Goma/Gisenyi – showing the imagery to local inhabitants) individual built-up structures using the VHR imagery for 2005, 2010, and 2014, and corrected the resulting vector data sets for geometric and topological errors. A spatial shift of up to 3 meters remained after image-to-image co-registration, due to different image acquisition angles and orthorectification procedures upon delivery. To minimize this effect, we aggregated the vector data to a coarser spatial resolution by converting the building polygons to centroids, then assigning each centroid to a 10-hectare cell of a hexagonal vector-grid. While a hexagonal grid is most often used for precise spatial sampling, it facilitates more effective visualization of spatial variations than a rectangular grid (Birch et al., 2007). We calculated building numbers and building density as well as their absolute and

relative changes between the time periods within these hexagonal grid cells. The resulting density maps served to identify points of interest for field visits, particularly areas that displayed a prominent increase or decrease in built-up area. To assess statistically significant differences in urban development (building density) between cities, we used Student's t-test with previous F-tests to control for heterogeneity of variances and considered differences to be statistically significant if p-values were below the 5% level.

2.3 Field Work

The quantitative findings were explored and contextualized through field observations and the elicitation of local knowledge by interviews conducted in Gisenyi and Goma in 2016 and 2017. During the fieldtrips, interviews and informal conversations were conducted on both sides of the border with various stakeholders such as state representatives, UN and NGO staff, members of the national and provincial administration and of religious and educational institutions, and informants with a long period of residency in Goma and/or Gisenyi (for more details, see also: Pech and Lakes (2017), Pech et al. (2018)). The interviews aimed at understanding the interviewees' perspectives, and were semi-structured. Each interviewee with a long residency in either town was asked about: their personal history, including their migration history, their housing circumstances, and changes to the city. When possible, sites or neighborhoods mentioned or cartographically identified by the interviewees were visited personally. Depending on their field of expertise, the interviewees then focused on socio-economic, political, and administrative topics, e.g., population movement to and between the cities, economic linkages, urban planning mechanisms, and humanitarian issues, with an emphasis on the role of armed conflict in these processes. Interviews were conducted in French or English, sometimes with the help of a translator (e.g., Swahili-French). Handwritten notes were taken during all interviews.

3 Results and Interpretation

The security situation, at the center of our analysis, and mapped and contextualized in section **3.1**., appears to be a major driver of urban growth, although there are large differences between time periods and the respective sides of the border. In addition, Goma's and Gisenyi's developments are shaped by (in)formal urban planning, and the economic situation, and integration of each city within its country. All key factors are interrelated and exhibit cross-border effects, as **Figure I-1** summarizes.

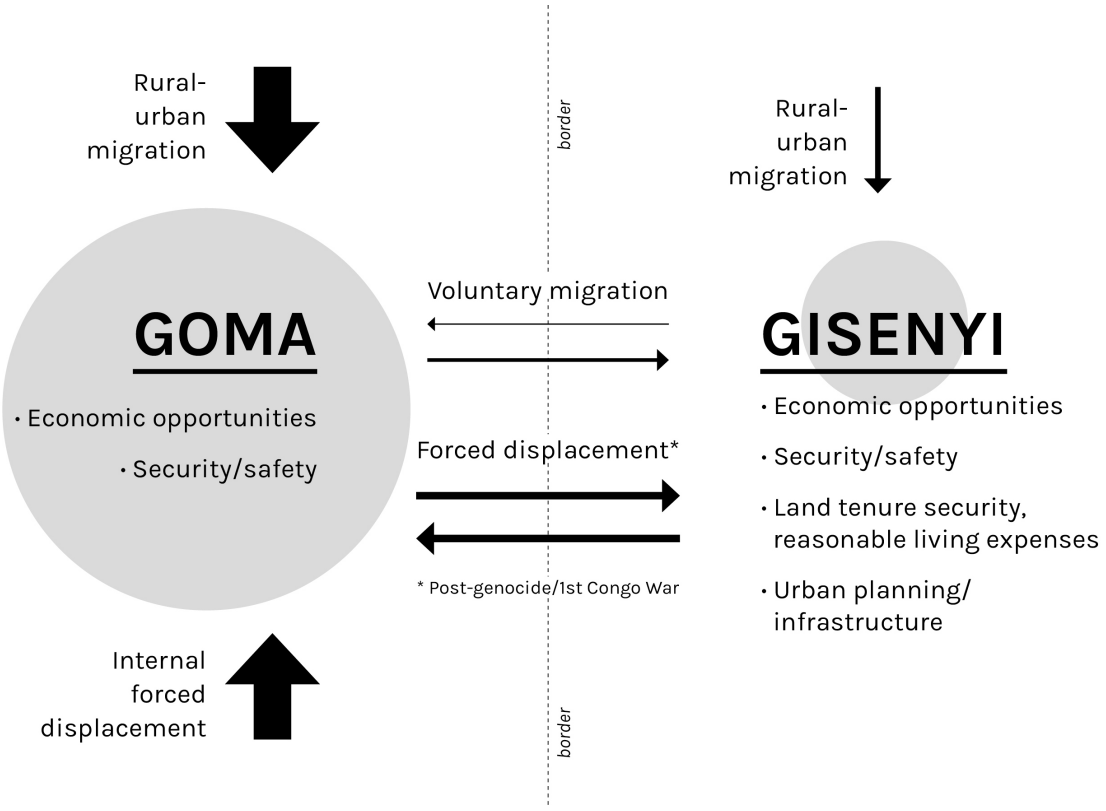

Figure IV-1: Simplified framework of factors affecting urban development in the study area

3.1 Mapping and Contextualizing Urban Development

Since Rwanda gained independence from Belgium in 1960, the principal victims of exclusion were its Tutsi inhabitants, which in turn rooted in political exclusion of Rwanda's Hutu under German and Belgian colonial rule. In Congo's North Kivu province, the closest analogues to the Rwandan population are the Banyarwanda (Rwandophones). The Banyarwanda include Hutu and Tutsi who migrated before, or were (involuntarily) re-settled during the colonial regime, and Tutsi who fled to Congo in 1959, in the wake of a Hutu revolution preceding Rwanda's independence (Lemarchand, 2004). In 1990, the Rwandan Patriotic Front (RPF), primarily consisting of Rwandan Tutsi-exiles from Uganda, invaded Rwanda, and many of the (Tutsi) Banyarwanda that had fled Rwanda in 1959 joined the rebellion (Prunier, 1997, Prunier, 2008). The resulting Rwandan civil war culminated in a genocide against Rwanda's Tutsi, and politically moderate Hutu. Gisenyi was the last Rwandan city to fall to the victorious RPF in July 1994, which marked the official end of the genocide and civil war. By this time, the town had experienced the near extinction of its Tutsi population (Prunier, 2008, Prunier, 1997). The victory of the RPF over the genocidal forces caused over a million Hutu to flee into eastern Congo in fear of retaliation. Amongst

these refugees were members of the former Rwandan government, army and militias, and hence people responsible for the genocide (Stearns, 2011, Umutesi, 2004, Vlassenroot, 2004). Many of the refugees settled close to the border in five different camps around Goma, large enough to be visible from space on relatively coarse Landsat imagery (**Figure IV-2**, center).[74] Goma expanded from 7 to 21.3 km² of which 5 km² were covered by refugee camps. Mugunga and Lac Vert being the main civilian refugee camps, even though they were tightly controlled by Rwandan (former) army and militia members, while the Bananeraie and Kituku were the residencies of higher army and militia ranks.[75] The enormous humanitarian and security problems associated with these camps, and the international community's failure to demilitarize them, have been well documented (Prunier, 2008, Stearns, 2011, Pottier, 1996, Umutesi, 2004).

In Gisenyi, a countermovement from Congo also led to an urban expansion (**Figure IV-2**, bottom). After the genocide, parts of Congo's Tutsi left the country in fear of reprisals by the newly arrived Hutu. Between 1995 and 1996, 34,000 of Tutsi moved or returned from North Kivu to Rwanda, taking up residence wherever they could find space. Throughout Rwanda, many of these people initially occupied houses and expropriated land of people who had died or fled (Stearns, 2011, Newbury, 2011). Others stayed in camps, as for instance in Gisenyi, in an uninhabited area named Mbugangari, north of the city center and adjacent to the Congolese border. Between 1994 and 1995, Mbugangari housed around 3,000 to 5,000 inhabitants.[76] The Rwandan administration supported this settlement actively, granting every returnee a parcel and land title in the area of the make-shift camp. Parcels were assigned

[74] Interviews with AN EMPLOYEE OF UN HABITAT GOMA 2016. Interview # 20, Interview in Gisenyi due to problems at the border. *In:* PECH, L. (ed.), A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.), AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise*, AN EMPLOYEE AND A VOLUNTEER AT THE DON BOSCO CENTER 2017. Interview # 49, Interview at Don Bosco Center Ngangi. *In:* PECH, L. & SCHUH, P. (eds.)., AN EMPLOYEE OF UNHCR GOMA 2016. Interview # 21, UNHCR Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *UNHCR.*,AN INHABITANT OF HIMBI/LOCAL CONSTRUCTION ENTREPRENEUR - GOMA 2016. Interview # 41, in Himbi. *In:* PECH, L. (ed.)..

[75] Interviews with AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise*, AN EMPLOYEE OF THE CONGOLESE RED CROSS 2016. Interview # 45, visit of IDP Camp Mugunga I and former IDP Site Lac Vert, Buhimba, Bulengo and Bananeraie. *In:* PECH, L. (ed.), AN EMPLOYEE OF UN HABITAT GOMA 2016. Interview # 20, Interview in Gisenyi due to problems at the border. *In:* PECH, L. (ed.).

[76] Interviews with A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.). and A RESEARCHER OF POLE INSTITUTE GOMA 2017. Interview - Cross Border Migration due to Insecurity/Infrastucture/Livelihood Opportunities. *In:* PECH, L. (ed.).

based on a law that permitted the erection of makeshift buildings on the administered parcel, and some assistance with construction materials was provided by donor aid; the former suburban fallow land was converted into an official neighborhood of Gisenyi.[77]

[77] Interviews with AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*, AN EMPLOYEE OF THE CONGOLESE RED CROSS 2016. Interview # 45, visit of IDP Camp Mugunga I and former IDP Site Lac Vert, Buhimba, Bulengo and Bananeraie. *In:* PECH, L. (ed.)., A RESEARCHER OF POLE INSTITUTE GOMA 2016a. Interview # 17, Interview in Gisenyi due to problems at the border. *In:* PECH, L. (ed.) *Pole Institute Goma.*, A RESEARCHER OF POLE INSTITUTE GOMA 2017. Interview - Cross Border Migration due to Insecurity/Infrastucture/Livelihood Opportunities. *In:* PECH, L. (ed.). and A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.).

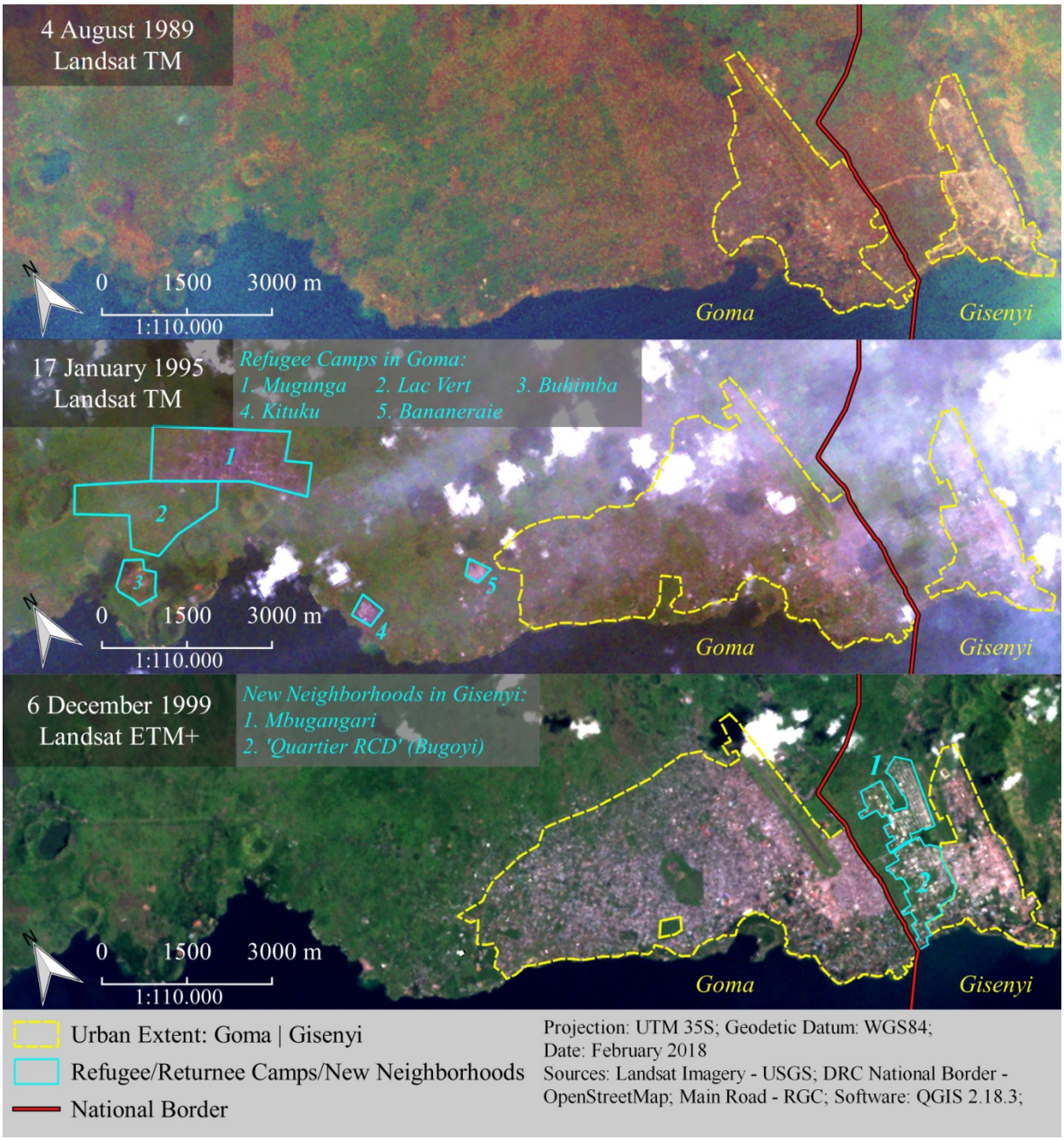

Figure IV-2: Goma/Gisenyi before the conflict onset (top); Refugee camps in Goma (center); Refugee/returnee camps in Gisenyi, converted into neighborhoods by the time of image acquisition (bottom).

In 1996, the Rwandan Patriotic Army (RPA), created after the RPF's victory, invaded Congo in pursuit of the genocide perpetrators (Prunier, 2008). The stated target of the Rwandan troops were former army and militia responsible for the genocide, but many Rwandan Refugees were forced to flee or killed during these attacks (Mathys, 2017, Newbury, 2011). The refugee camps were emptied and destroyed within days which led to a temporary diminution of Goma's area (**Figure IV-2**, bottom). Camp structures, such as parcels, paths and sometimes latrines were reused during Goma's subsequent urban expansion, and for the

erection of several IDP camps during the successive Congolese conflicts. [78] According to contemporary witnesses,[79] within just a few days, no trace of the camps remained. Due to unfavorable cloud conditions, the earliest available imagery dates to October 1999, and we thus strongly relied on information from the literature and from contemporary witnesses.[80].

Triggered by the Rwandan refugee influx, Congo's Banyarwanda split between Hutu and Tutsi communities, and several rebel organizations emerged (Verpoorten, 2012, Reyntjens, 1999, Lemarchand, 2012). During 1997 and 1998 Rwanda's northeast including Gisenyi suffered from cross-border attacks by (Hutu) guerillas, targeting army installations and Tutsi returnee-camps close to the border (Newbury, 2011, Johnson, 2014). Today, refugee camps are located in central parts of Rwanda, motivated by a decision of the Rwandan Government and the UN High Commissioner for Refugees (UNHCR).[81] Even though the post-genocidal violence in Rwanda had its peak in 1997, isolated incidents until the present day served to justify Rwandan military involvement in eastern Congo (Verpoorten, 2012, Johnson et al., 2016). During the first Congo War (1996-1997) Congo's[82] president Mobutu was overthrown by a Rwandan and Ugandan backed insurgency, led by the Congolese Laurent Désiré Kabila. Kabila soon turned against his allies using the support of Hutu militias, thereby triggering the Second Congo War (1998-2003), which split the country into various zones of military control. Goma was conquered in August 1998, and from then on administered by the Rwandan backed (Goma) faction of the rebel movement Rally for Congolese Democracy (RCD-G). Laurent Désiré Kabila was assassinated in 2001 and succeeded by his son Joseph (Berwouts, 2017, Tull, 2005, Stearns, 2011). In January 2002 Mount Nyiragongo erupted

[78] Interviews with AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise*, AN EMPLOYEE OF THE CONGOLESE RED CROSS 2016. Interview # 45, visit of IDP Camp Mugunga I and former IDP Site Lac Vert, Buhimba, Bulengo and Bananeraie. *In:* PECH, L. (ed.), AN EMPLOYEE OF UNHCR GOMA 2016. Interview # 21, UNHCR Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *UNHCR.*

[79] Due to unfavorable cloud conditions, the earliest available imagery dates to October 1999, and we thus strongly relied on information from the literature and from contemporary witnesses.

[80] Interview with AN INHABITANT OF GOMA 2016. Interview # 13, several interviews with the same interviewee. *In:* PECH, L. (ed.)., AN EMPLOYEE OF UN HABITAT GOMA 2016. Interview # 20, Interview in Gisenyi due to problems at the border. *In:* PECH, L. (ed.)., AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise.*

[81] Interview with AN EMPLOYEE OF THE CONGOLESE NATIONAL COMMISSION FOR REFUGEES (CNR) 2017. La Situation des Réfugiés en RDC. *In:* PECH, L. (ed.).. The African Union Convention on the Governance for Specific Refugee Problems in Article 2 (6) states: "For reasons of security, States of asylum shall, as far as possible, settle refugees within a reasonable distance of the border of their country of origin."

[82] back then named Zaire, but for simplicity reasons we only use Congo and DRC throughout this article.

and destroyed a third of Goma's built-up area, leaving between 12,000 and 14,800 families homeless (Kanene, 2014, Pech and Lakes, 2017). The lava did not cross into Rwanda, and Gisenyi was temporarily affected through the influx of people from Goma in search for shelter. Due to the RCD's inaction concerning evacuation and humanitarian aid, people who had the financial means moved permanently to Gisenyi, out of the (persisting) believe that Gisenyi is not threatened by the volcano. Simultaneously, many higher RCD-G ranks moved to Gisenyi [83],encouraged by a relaxed border regime due to strong ties between the RCD-G and Rwanda (Doevenspeck, 2011, Tull, 2005). As the RCD-G cadres mostly rented or bought parcels in Gisenyi's Bugoyi neighborhood, until then a no-mans-land between Goma and Gisenyi, the cities began to merge physically (**Figure IV-2**, bottom).[84]

In 2003, following several peace agreements, the RCD was integrated into the Congolese transitional government (Veit, 2010), and many of quartier RCD's inhabitants moved to Congo's capital Kinshasa. They were replaced by middle class Congolese, and Quartier RCD continued to grow. Reasons for Congolese to move were the loss of their homes in Goma during the volcanic eruption, and the fear of a new eruption and the incapacity of the RCD-G to organize humanitarian aid and reconstruction. A better quality of life on the Rwandan side (urban infrastructure such as electricity, water, and sanitation, lower crime rates, better schools, health services), more affordable rents, and a more trustworthy land title awarding system also draw people from Goma to live in Gisenyi. Furthermore, houses in Gisenyi often feature small yards or gardens, which render subsistence gardening feasible, and are also attractive for leisure, as both cities suffer from a lack of public open (green) spaces [85] As the

[83] Even though, depending on the location of volcanic fissures, Gisenyi is exposed to the same volcanic threat as Goma, the believe that only Goma is threatened persists among Goma's inhabitants AN EMPLOYEE OF MONUSCO'S GIS UNIT 2016. Work of GIS Unit, mapping, hazard analysis. *In:* PECH, L. (ed.), AN EMPLOYEE OF GOMA'S OBSERVATOIRE VOLCANOLOGIQUE (OVG) 2017. Volcanic Vents, Hazard and Affected Areas in the Case of Future Outbreaks,. *In:* PECH, L. (ed.).. Further interviews with AN EMPLOYEE OF UN HABITAT KINSHASA 2016a. Interview # 6, UN Habitat Kinshasa *In:* PECH, L. (ed.) *UN Habitat.*, A RWANDAN INHABITANT OF BUGOYI/QUARTIER RCD IN GISENYI 2017. Histoire du Quartier RCD. *In:* PECH, L. (ed.), AN INHABITANT OF GOMA 2016. Interview # 13, several interviews with the same interviewee. *In:* PECH, L. (ed.), A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.)..

[84] Interviews with A CONGOLESE INHABITANT OF BUGOYI/QUARTIER RCD IN GISENYI 2017. Interview Goma-Gisenyi - Migration between the two cities. *In:* PECH, L. (ed.), A RWANDAN INHABITANT OF BUGOYI/QUARTIER RCD IN GISENYI 2017. Histoire du Quartier RCD. *In:* PECH, L. (ed.).

[85] Similar to the current law in the DRC, all Rwandan soil belonged to the state according to a law passed in 1961, until the reform in 2005. The new law facilitates the transfer of land titles and legalized land acquired under traditional law ILBERG, A. 2009. Einflussfaktoren auf Wachstum und Morphologie informeller Siedlungen.. Most of the parcels in Gisenyi are "private state land" and rented or leased for 99 years. (Interviews with A CONGOLESE INHABITANT OF BUGOYI/QUARTIER RCD IN GISENYI 2017. Interview Goma-Gisenyi - Migration between the two cities. *In:* PECH,

mapped analysis of our VHR data shows, with 50 to 200 buildings per 10.4 ha hexagon, no fallow land remained in 2005 in Gisenyi's Bugoyi (RCD) neighborhood in the city's southern part along the border (**Figure IV-3**, top**).**

On the Congolese side, violence never came to a halt despite several peace accords. Between 2004 and 2014, several outbreaks of violence occurred. Due to a combination of permanent insecurity and a radical decline of agricultural modes of production in Kivu's rural areas, Goma and comparable cities in North Kivu received waves of internally displaced people and people looking for better livelihood opportunities (Raeymaekers, 2013). IDP camps in the city's western neighborhoods where erected, closed and re-opened throughout these episodes of insecurity (**Figure IV-3**, center and bottom).[86]

In October 2008, the Congrès National pour la Défense du Peuple (CNDP), a predominantly Tutsi movement, threatened to capture Goma. Following negotiations, Joseph Kabila allowed Rwandan soldiers into the DRC to neutralize Hutu militia forces. Subsequently 6,000 CNDP combatants were integrated into the Congolese army, and a peace treaty was signed on March 23 of 2009 (Johnson et al., 2016, Johnson, 2014). Armed confrontation resumed in 2012, as integrated CNDP combatants mutinied and founded the M23 movement, named after the date of the peace treaty. M23 seized Goma between November and December 2012. By September 2013, the estimated number of IDPs in North Kivu was more than a million (UN OCHA, 2012, IDMC, 2014).

L. (ed.). and AN EMPLOYEE OF THE ONE STOP CENTER OF RUBAVU DISTRICT 2017. Urban Planning and Administrative Structures of Rwanda. *In:* PECH, L. (ed.)..

[86] Interview with AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*

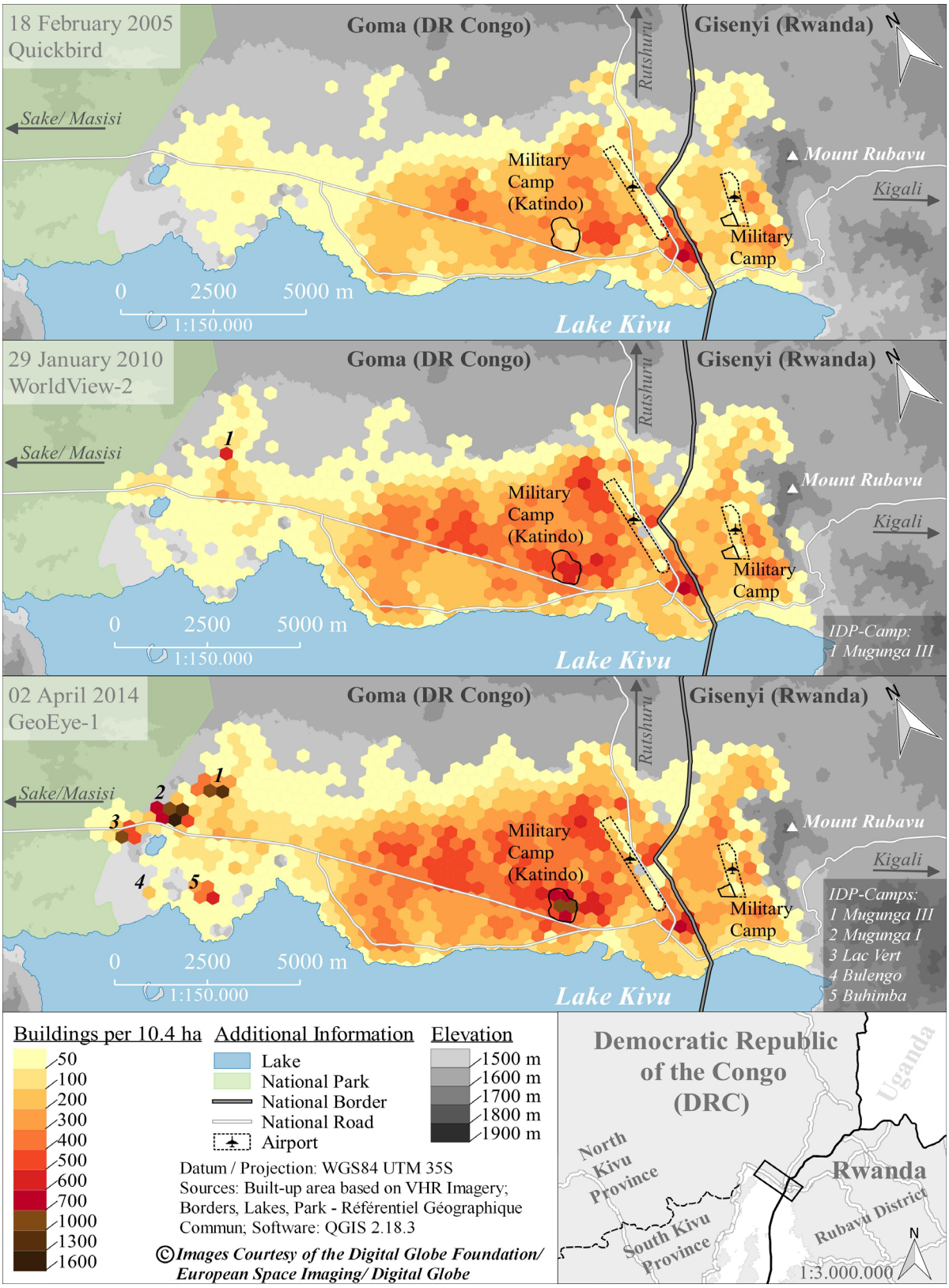

Figure IV-3: Goma's and Gisenyi's Built-Up Area in 2005, 2010 and 2014. Buildings per 10.4 ha.

The incessant insecurity in North and South Kivu drove the densification of Goma's urban built-up area with the relocation of IDPs to up to seven IDP camps and throughout the city, requiring rapid residential construction.[87] Up to 62 percent of North Kivu's IDPs were estimated to live outside of camps, and between 2012 and 2013, Goma's population increased approximately 45 percent (Norwegian Refugee Council, 2014). Among the highest building densities with up to 700 buildings per hexagon (in 2014) were measured in Goma's traditional business district Birere along the border (dark red tones in **Figure IV-3**). Even Goma's main military camp Katindo **was** built up entirely due to the influx of military members, often joined by their families, and by internally displaced persons and other civilians (dark red and brown tones in **Figure IV-3**) (Pech et al., 2018). As a matter of contrast, on the Rwandan side, where the conditions were relatively stable, the military camp in Gisenyi next to the city's airport remained almost entirely devoid of buildings. Gisenyi itself also remained at a lower building level.

As refugees are no longer allowed to settle close to the border, Congolese displaced persons intending to cross the border together with late Rwandan returnees are accompanied to the border by the Congolese National Refugee Commission (CNR), and in Gisenyi brought to the UN HCR transit center by Rwandan HCR members. Refugees are then transferred to one of the five Congolese refugee camps in central Rwanda, some of which exist since 1996. Rwandan returnees, including demobilized (rebel) combatants, are registered and provided with basic assistance before they are transported to their districts of origin, where they receive reintegration assistance.[88] Today, permanent settlement of cross-border migrants from Goma to Gisenyi comprises two main groups: international staff with family (since Goma is a non-family duty station), and Congolese middle-class citizens in search of a safer, more stable setting with less delinquency, a reliable urban infrastructure (paved roads,

[87] Interviews with ibid., AN INHABITANT OF GOMA 2016. Interview # 13, several interviews with the same interviewee. *In:* PECH, L. (ed.). and AN EMPLOYEE AND A VOLUNTEER OF THE CONGOLESE RED CROSS 2016. Interview # 14 , Congolese Red Cross Goma (Interview in Gisenyi, Rwanda due to problems at the border). *In:* PECH, L. (ed.) *Croix Rouge Congolaise.*.

[88] [88] Interviews with A CONGOLESE INHABITANT OF BUGOYI/QUARTIER RCD IN GISENYI 2017. Interview Goma-Gisenyi - Migration between the two cities. *In:* PECH, L. (ed.)., A RESEARCHER OF POLE INSTITUTE GOMA 2017. Interview - Cross Border Migration due to Insecurity/Infrastucture/Livelihood Opportunities. *In:* PECH, L. (ed.)., AN EMPLOYEE OF THE CONGOLESE NATIONAL COMMISSION FOR REFUGEES (CNR) 2017. La Situation des Réfugiés en RDC. *In:* PECH, L. (ed.)., A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.)., AN EMPLOYEE OF UN OCHA KINSHASA 2016b. Interview # 2, Coordination and Evaluation Officer: Planning and Ressource Mobilisation Unit at UN OCHA. *In:* PECH, L. (ed.). and AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*

electricity network, sanitary infrastructure etc.), affordable food, and reasonable housing costs.[89] Privileged locations in Goma are scarce, and prices are more affected by speculation and corruption (Peyton, 2018a).

3.2 Differences in Expansion, Densification and Building loss

Based on the analysis of our VHR data (2005-2014), Goma's extent in built-up area (39 km²) was more than four times Gisenyi's size (9 km²) in 2005. Goma covers a substantially larger area than Gisenyi and expanded more rapidly throughout ten years of urban development. The city's extent was 44 km² in 2010 (+5 km² or +12.8%) and 57 km² in 2014 (+18 km² or + 46.2%), while Gisenyi's extent was 10 km² in 2010 (+1 km² or +11.1%) and 11 km² in 2014 (+2 km² or + 22.2%).[90] Nevertheless, Goma's 7.17 buildings per hectare and Gisenyi's 6.60 buildings per hectare demonstrate that building densities did not differ significantly in 2005 ($p = 0.400$, CI = -0.77, 1.92) (**Figure IV-4**, left panel). This changed in 2010 and 2014, when mean building densities were significantly higher in Goma (2010: 11.54; 2014: 15.76) compared to Gisenyi (2010: 9.16; 2014: 11.58) with $p < 0.005$ (2010) and $p < 0.005$ (2014) as well as CI = 0.77, 3.99 (2010) CI = 2.24, 6.12 (2014). Additionally, very high building densities characterized several areas of Goma, while the density in Gisenyi was distributed homogeneously with very few outliers. Though both cities exhibited an increase in building density between 2005 and 2014, Goma's mean building density increased significantly more (+8.59 buildings per hectare) than Gisenyi's (+4.98 buildings per hectare) with $p < 0.0005$ and CI = 2.25, 4.96.

[89] Interview with A RESEARCHER OF POLE INSTITUTE GOMA 2017. Interview - Cross Border Migration due to Insecurity/Infrastucture/Livelihood Opportunities. *In:* PECH, L. (ed.).
[90] Measurements based on original shapefiles of built-up area

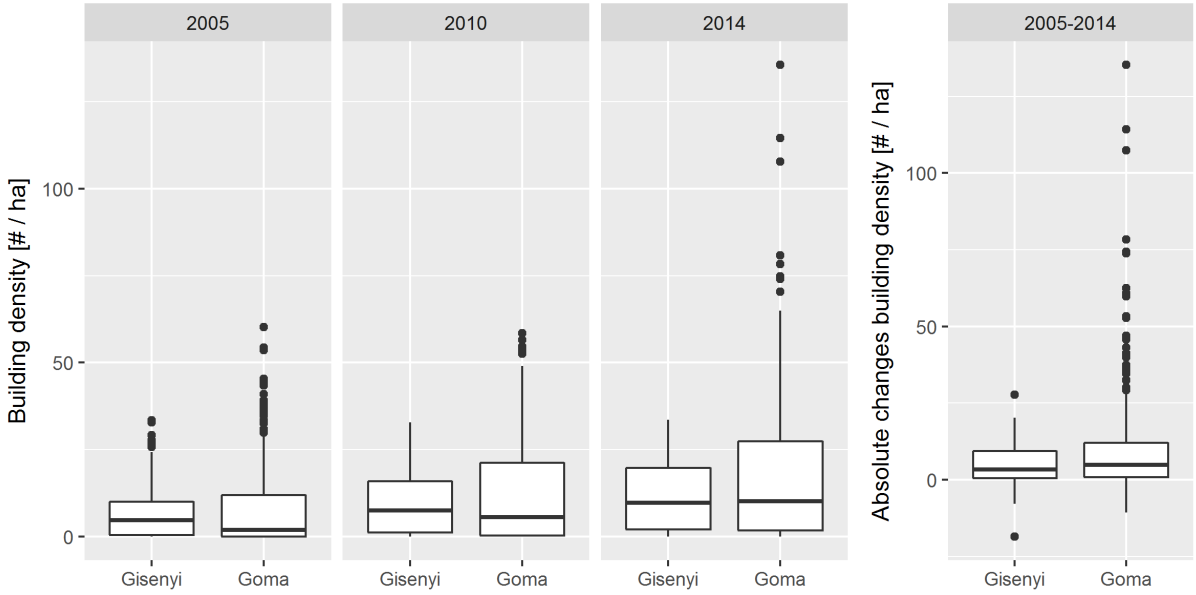

Figure IV-4: Differences in building densities

The change analysis (**Figure IV-5**), based on the 2005 image footprint, shows relative changes in built-up area between 2005 and 2014. The (northward) expansion (grey-brown) and densification (red) is stronger in Goma than in Gisenyi. In Goma's western neighborhoods Mugunga and Lac Vert, an area with 600 buildings per 10.4 ha in 2005 was joined by four areas of between 600 and 1600 buildings per hexagon in 2014 (red tones). Densely built-up areas also sprung up in central Goma, within a kilometer-wide fringe north of the westbound main road, and in Goma's military camp (red tones). Higher density of built-up area exists in Gisenyi to a much smaller magnitude than in Goma, with 400 buildings per hexagon in the (colonial) center (Rubavu neighborhood) and north of this center (Byahi neighborhood). A loss of buildings occurred in Goma along the border, mostly in the central Birere neighborhood and punctually along Goma's westbound main road (blue tones). In Gisenyi's east, loss of buildings happened along Mount Rubavu's western slope (blue). Due to topographic (lake, national park) and administrative (national and municipal borders) constraints, both cities expand mainly northwards.

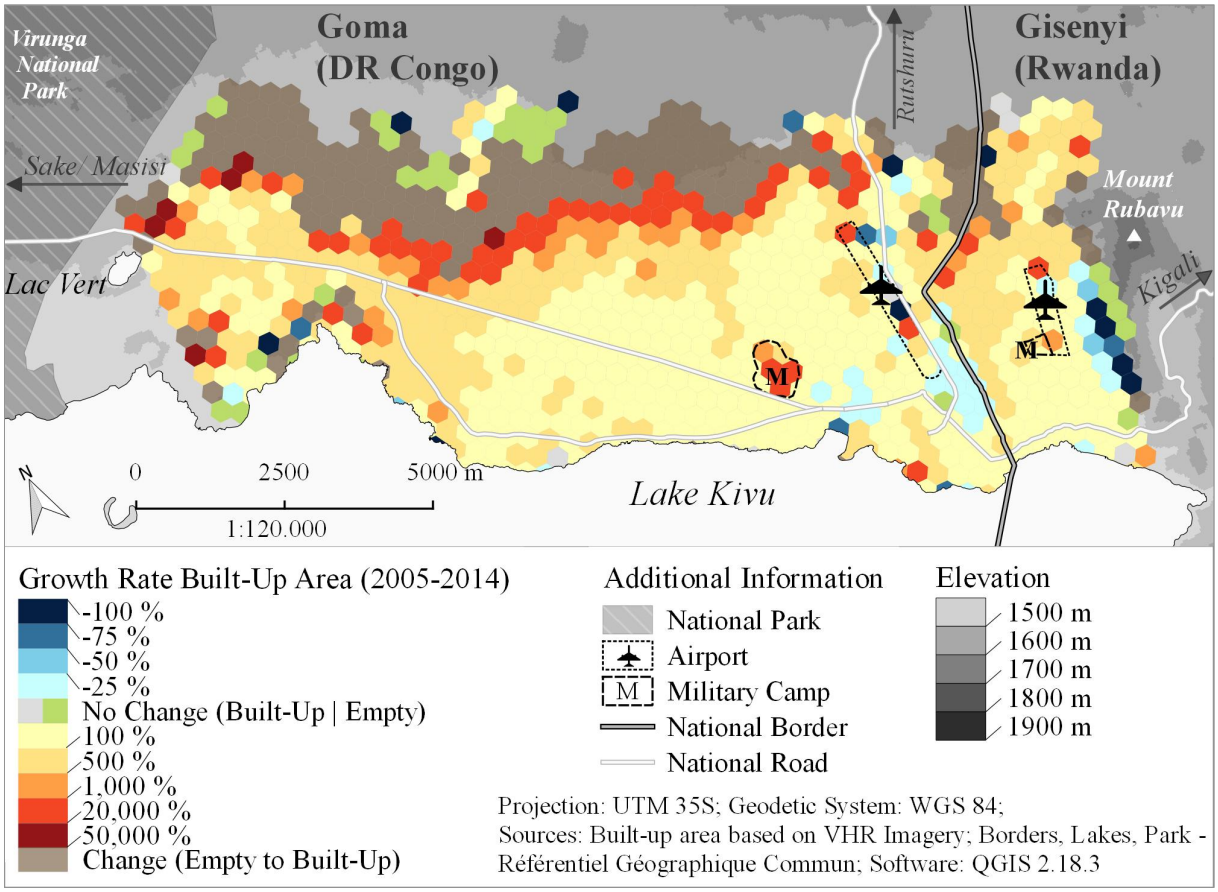

Figure IV-5: Expansion, Densification and Building Loss in Goma and Gisenyi between 2005 and 2014

Not all changes in built-up structures on either side of the border are conflict related. However, while on Goma's side rural-urban migration is most often linked to the security situation, and reliable demographic data does not exist for Goma, we will here discuss the disappearance of buildings to illustrate how urban growth is controlled on both sides of the border.

Gisenyi's moderate expansion is not only due to the absence of open armed conflict in Rwanda's recent past. The Rwandan capital of Kigali has been at the center of the attention of urban modernization endeavors in Rwanda since the end of the civil war (Pätsch, 2018), and federal development mandates for secondary towns have mostly been sidelined (Newbury, 2011, Huggins, 2017). Thus far, the capital has attracted most of the rural-urban migration within the country. Half of Rwanda's urban inhabitants live in Kigali (Goodfellow, 2014). Gisenyi only got its first masterplan in 2015, as part of national ambitions to promote secondary cities, involving Gisenyi's promotion as tourist hub (LODA, 2017). Prior to the enactment of the masterplan, the Rwandan government had implemented ambitious policies to handle uncoordinated urbanization by designating urban zones into building plots to provide relevant infrastructural services for all cities, which to a great deal involved the

clearance of unplanned urban areas (Ansoms and Rostagno, 2012, Huggins, 2017, Newbury, 2011). An example of such clearances is the diminution of built-up area in Gisenyi. More than hundred buildings were demolished on Mount Rubavu's western flank between 2010 and 2014 (light to dark blue hexagons in **Figure IV-5**), officially ordered due to the exposition to landslide hazard. Subsequently, Mount Rubavu was declared as a natural preserve.[91] Since a land reform in 2005, the Rwandan state officially recognizes the right to own land. Land titles enable possession for 99 years or a 20-year leasehold unless the government decides to expropriate in 'public interest' (Ilberg, 2009, Pätsch, 2018). As officially the expropriated inhabitants must be compensated, they were granted monetary aid and replacement parcels in Gisenyi's north. Nevertheless, in practice, many people were obligated to destroy their homes and then construct elsewhere with too little or no assistance (Newbury, 2011). The establishment of informal settlements is significantly hampered in Gisyeni (and nationwide) by neighborhood monitoring efforts that to render illegal settlement difficult.[92] These mechanisms of governance collectively inhibit unplanned urban change, in stark contrast to Goma, where the urbanization process has unfolded in a relatively organic, spontaneous, and unplanned way (Pech et al., 2018). By contrast, Goma's larger city area and the state's administrative (in)capacity, combined with a permanent crisis situation, render the planning and controlling of Goma's ongoing expansion difficult.[93]

The change analysis (see also **Figure IV-5**) also shows building loss on Goma's side along the border, due to an endeavor to create an avenue using uncoordinated bulldozing. This haphazard plan left many buildings partially or fully destroyed and their inhabitants homeless without compensation.[94] Additionally, between 2015 and 2016 (after our satellite

[91] Interviews with A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.)., A RESEARCHER OF POLE INSTITUTE GOMA 2017. Interview - Cross Border Migration due to Insecurity/Infrastucture/Livelihood Opportunities. *In:* PECH, L. (ed.)., A CONGOLESE INHABITANT OF BUGOYI/QUARTIER RCD IN GISENYI 2017. Interview Goma-Gisenyi - Migration between the two cities. *In:* PECH, L. (ed.). and AN EMPLOYEE OF THE ONE STOP CENTER OF RUBAVU DISTRICT 2017. Urban Planning and Administrative Structures of Rwanda. *In:* PECH, L. (ed.)..

[92] Informal background talk with AN EMPLOYEE OF THE RWANDAN MINISTRY OF INFRASTRUCTURE 2017. *In:* PECH, L. (ed.).. Interview with AN EMPLOYEE OF UN HABITAT GOMA 2016. Interview # 20, Interview in Gisenyi due to problems at the border. *In:* PECH, L. (ed.).

[93] Interview with A RESEARCHER OF POLE INSTITUTE GOMA 2017. Interview - Cross Border Migration due to Insecurity/Infrastucture/Livelihood Opportunities. *In:* PECH, L. (ed.).

[94] Interview with AN EMPLOYEE OF UN OCHA KINSHASA 2016a. Interveiw # , Humanitarian Affairs Officer, UN OCHA Kinshasa. *In:* PECH, L. (ed.)., A MASTER'S STUDENT FROM GOMA AT ISAU 2016. Interview # 32, Institut Superieur d'Architecture et d'Urbanisme (ISAU). *In:* PECH, L. (ed.) *Titres Fonciers, Planification Urbaine et Développement Urbain - Goma.*

imagery analysis ends) at least 198 buildings were destroyed in a similar manner along the border in Birere. Allegedly, this clearance of the 'neutral zone' between the DRC and Rwanda took place to prevent further territorial conflicts and infiltration (armed groups, bandits). The idea was born in 2009 by a joint commission between the DRC and Rwanda, but demolition began only in August 2015, supervised by Congolese and Rwandan soldiers. It was agreed that 6.25 meters should be cleared on both sides of the border, with compensation for the expropriated on the Rwandan side (Belga/La Libre.be, 2015).[95] During the first author's last visit to the border strip in October 2017, still, no clearance had occurred on the Rwandan side. Lacking alternatives, the affected Congolese continued to live in partly demolished buildings, in tents, or banana groves.[96] They were not compensated, as the Congolese authorities claim that they knowingly settled illegally, despite the inhabitants claiming to have built their accommodations after obtaining approvals issued by a mayor or traditional chief (Belga/La Libre.be, 2015). However, as two land-tenure systems co-exist in Goma, given land titles are not necessarily a reliable guarantee of possession.[97]

4 Conclusion

Goma and Gisenyi feature distinct parallels in their development, such as their increased spatial extent due to the influx of forcibly displaced persons. Nevertheless, the ways how these flows of displaced persons are (spatially) governed by the respective country differ. Additionally, due to the absence of armed conflict in Rwanda since the early 2000s, no conflict-induced internal forced displacement to urban areas occurs, and (Congolese) refugees are not allowed anymore to settle close to the border.

In both cities, we also observed areas where buildings had disappeared. Goma exhibited rapid and extreme densification of buildings in many areas marked by poor living conditions,

[95] Interview with A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.).

96 Interviews with A MASTER'S STUDENT FROM GOMA AT ISAU 2016. Interview # 32, Institut Superieur d'Architecture et d'Urbanisme (ISAU). *In:* PECH, L. (ed.) *Titres Fonciers, Planification Urbaine et Développement Urbain - Goma.*, A MEMBER OF THE RWANDAN RED CROSS 2017. Interview - Genocide, Civil War and (Forced) Migration. *In:* PECH, L. (ed.)., AN INHABITANT OF GOMA - MIKENO 2016. Interview # 40, in Mikeno/Birere. *In:* PECH, L. (ed.)., A POLICE OFFICER, B. G. 2017. Birere, Destruction of Buildings on Border Strip. *In:* PECH, L. (ed.)., AN EMPLOYEE OF BUREAU D'ÉTUDES D'AMENAGEMENT ET D'URBANISME (BEAU) 2016. Interview # 31, Office for land-use planning and urban planning. *In:* PECH, L. (ed.)..

97 Interview with AN EMPLOYEE OF UN HABITAT 2016. Interview # 37, UN Habitat Goma. *In:* PECH, L. (ed.) *UN Habitat Goma.*

whereas the equivalent spaces in Gisenyi often featured small yards or gardens, despite the concentrations of very modest living conditions. Despite their interdependencies, Gisenyi remains less internationally integrated, both economically and politically, than Goma. These processes and configurations are not exclusively resultant from armed conflict, but also through interplays of livelihood opportunities, cross-border economies, divergent trajectories and degrees of statehood, and transnational actors (such as the UN). The main flow of Rwandans to Goma consists of commuters, while Gisenyi is home to some people who make their living in Goma but prefer to live in Gisenyi. In Rwanda, the capital Kigali is still a significant magnet for rural-urban migration. Nevertheless, our results indicate that conflict is a crucial accelerator of urban change.

However, the drivers of urban change are not strictly separable nor linkable to only one growth phenomenon. Further research efforts should utilize comparative approaches to identify, situate, and disentangle the factors driving urban growth and decline in conflict-affected borderlands. Household surveys could use similar building data layers as a basis for improved estimation of the number and composition of the population, or a comparison of the quality of life on both sides of the border.

The ability to leverage remote-sensed imagery poses an invaluable tool for identifying patterns and areas of interest, and recent advances in image analysis may provide semi-automated tools to better quantify changes in urban structure and configuration. Crucial to their use is the elucidation of complex and intertwined social, political, and economic ecologies, and the tracing of their endemic effects on urban change. We assert that this relies on communication with a diverse set of actors, and therefore underscore the utility of integrated approaches to urban research.

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Goma and Gisenyi, Airports (2014)

Chapter V:
Synthesis

1 Synthesis

This dissertation provides insights into the spatial repercussions of armed conflict on urban development in secondary cities in Sub-Saharan Africa. I do so by applying a methodological mix that combines two approaches: the spatial analysis of satellite imagery and in situ field research methods. Therefore, I leverage and integrate two separate approaches, thus providing a dual perspective on conflict-induced urban development. Goma and Gisenyi in the Congolese-Rwandan borderland serve as the case study cities. By spatially analyzing the expansion and densification of Goma's built-up area, and by chronologically linking these spatial processes to different phases of conflict, the first article of this dissertation advances our understanding of how different waves of forced migration shape urban expansion. The second article demonstrates in detail what constitutes these expansion processes on the building level, and uses examples based on field data collection to illustrate some of the main actors responsible for construction, extending the analysis beyond forced displacement. The third and final article of this dissertation compares urban expansion and densification across the Congolese-Rwandan border, again linking these processes to phases of armed conflict.

1.1 Main Findings

Cities in conflict zones play important roles, as they constitute political and administrative centers, points of economic exchange, zones of concentrated military power, and magnets for forced displacement and humanitarian response. The analysis showed that every conflict episode leaves traces on (both) cityscapes.

To summarize the methodological and thematic insights of this work, the main findings are structured along the research questions initially presented in Chapter 1 of this thesis.

RQ 1: What are the effects of protracted armed conflict on urban development at a) the overall urban and b) the intraurban levels?

Selected as an example for comparable secondary cities in the conflict-ridden African Great Lakes Region, Goma has faced the degradation of urban infrastructure during successive conflicts, while at the same time experiencing new urban growth and densification.

Goma and Gisenyi were heavily affected by trans-border refugee flows during and after the Rwandan Civil War and genocide, and the following Congo Wars. Today, Goma still is affected by internal displacement due to the precarious security situation in North and South Kivu. A large number of international development/aid, humanitarian, and peacekeeping

personnel and an increasing national military presence contribute to Goma's growth. Additionally, Congolese, Rwandans, and international businesspeople regard Goma as a city of economic opportunity.

Chapters II and III focus on Goma as an initial site, and chapter IV then extends and deepens this approach by comparing and contrasting Goma and Gisenyi, in order to answer the following research question:

RQ 1a: What are the effects of protracted armed conflict on urban development at the overall urban level?

The areas of both cities expanded during the study period (1980-2014). Goma was (and still is) strongly influenced by forced migration due to armed conflicts in Rwanda (past) and Congo (ongoing). Goma's built-up area has been expanding continuously. Two different types of expansion of built-up areas were identified: first a continuous westward expansion caused by general expansion of urban area, due to rural-urban migration and forced displacement, and to a relocation of parts of Goma's population. Second, a fragmented development, caused by the emergence of large camps. These camps first emerged with people fleeing neighboring Rwanda, and, after their (forced) closure, these areas were the later location for (Congolese) IDP camps. The (ongoing) closure and reopening of these camps caused the fragmented development of the outskirts of Goma. As the city expanded westward, these camps merged into the city area. In addition to forced migration caused by different armed conflicts, the eruption of Mount Nyiragongo (2002) had an impact on Goma's development, causing internal displacement within the administrative area of the city and increasing the expansion of built-up areas. By sheer luck, the eruption did not directly impact Gisenyi, although future eruptions could impact both sides of the border.

During the study period, Gisenyi expanded and densified only moderately. However, although it was a similar size to Gisenyi before the onset of civil war in Rwanda (1990), Goma measured about five times the built-up area (57 km²) of Gisenyi (11 km²) by the end of the satellite imagery analysis (2014). Building densities were significantly higher in Goma than in Gisenyi at the end of the observation period, and very high building densities characterized several areas of Goma, while the building density in Gisenyi was comparably homogeneous. Nevertheless, the results indicate that conflict was and is a key accelerator of urban change on both sides of the border.

RQ 1 b: What are the effects of protracted armed conflict on urban development at the intraurban level?

Chapters III and IV show that between 2005 and 2014, a period that corresponds to two major episodes of the intensification of violence in North Kivu, the number of buildings in Goma more than doubled (57,087 in 2005 vs. 116,278 in 2014). Growth rates and patterns differed between neighborhoods, and urban expansion and densification mainly occurred along the axes towards the west and the north. Most of the observed growth and densification took place around displacement camps in the city's western outskirts and, in Goma's core, in the built-up area towards the Rwandan border through Goma's traditional business district. Impressive increases in built-up area also occurred in Goma's military camp (152 buildings in 2005 and 2,209 in 2014). Privileged neighborhoods, most of which are located close to the shore of Lake Kivu, remain relatively stable in their loosely built-up structure. Furthermore, urban development in Goma took and takes place in a mostly unplanned (or not officially planned) manner and construction of urban infrastructure (e.g., roads, social housing) is mostly undertaken by non-state actors.

Following from the analysis of individual settlement patterns, a link to individual drivers of urban development processes could be established, which include repercussions of (forced) migration due to insecurity, spatial consequences of the decades-long presence of international agencies, militarization in the cityscape, and the impact of church-based social action. Furthermore, the mixture of voluntary and forced migration due to violence and war, and the expectation of employment in Goma, is illustrated by the building-level example of one of Goma's inhabitants in chapter III: Originally coming from Burundi, this inhabitant of one of the most densely populated areas of the city eventually moved to Goma out of a mixture of economic and security reasons. After having relocated several times due to the insecurity in in Burundi and then in Congo's rural east, she moved to Goma and became the domestic worker of a UN employee.

RQ 2: How does conflict affect cross-border differences in urban growth patterns?

Chapter IV shows that cross-border differences in spatial development between Goma and Gisenyi exist. Goma grew faster and is larger and more densely built-up than Gisenyi. Accordingly, Gisenyi's development takes place in a more moderate manner. Goma generally lacks urban infrastructure and planning, and its growth follows organic patterns. The satellite imagery analysis revealed a smaller size and a lower average density of Gisenyi's built-up area.

Both cities experienced effects of the Rwandan Civil War and genocide in the 1990s. Gisenyi's temporal desertion was followed by the influx of Tutsi returnees with the RPF's victory over the genocidal forces in Rwanda, and the massive Hutu exodus to Congo. As described in chapter IV, large refugee camps spread on both sides of the border in the cities' adjacent fallow lands. In Gisenyi, the camps quickly became official neighborhoods, while they were destroyed in Goma. Since then, IDP camps set up at this location have routinely been closed by the Congolese national police, to demonstrate that the security situation in the region is under control. During the subsequent Congo Wars, voluntary migration from Goma to Gisenyi by members of the politico-military elite was encouraged through political ties to the Rwandan regime. This 'elite settlement' mainly took place on uninhabited land between the two cities, and led to the geographical merging of built-up areas of Goma and Gisenyi.

The main flow of Rwandan workers, merchants, and students to Goma consists of commuters, while Gisenyi is home to some people who make their living in Goma but prefer and can afford to live in infrastructurally better-equipped and safer Gisenyi. Rwanda's security apparatus is tightly organized, and Gisenyi has the lowest crime rate in Rwanda. Conversely, Goma's crime rate ranks among the highest in Congo, and the city has been occupied or besieged by armed groups multiple times. In Rwanda, the capital Kigali is still a major magnet for rural-urban population. Additionally, due to the absence of armed conflict in Rwanda since the early 2000s, no conflict-induced internal forced displacement to urban areas occurs, and (Congolese) refugees are not allowed anymore to settle close to the border.

1.2 Key Implications of the Dissertation

Spatial Repercussions of Armed Conflict on Urban Land Use

The aim of this dissertation was to address key gaps in current research on the spatial development of (secondary) cities in conflict areas in Sub-Saharan Africa, by adding a spatial perspective to earlier studies of Goma. Earlier findings were confirmed: cities such as Goma, surrounded by conflict, experience relative security, or at least an absence of open armed conflict within city boundaries, in contrast to the situation in their hinterlands. Armed conflict accelerates rural-urban migration and therefore urban growth. Goma has been growing in an unplanned, fragmented fashion and has been transformed from a provincial border post to an important regional urban center with a large military and international (agency) presence. Urban development tasks are rarely planned or carried out by the Congolese national or provincial administration, but rather by the international community,

aid agencies, churches, and Goma's inhabitants themselves (Büscher, 2011, Verhoeve et al., 2004, Peyton, 2018b). As the search for safety is a major factor of growth in towns along the border between the DRC and Rwanda (Soi and Nugent, 2017, Behrends, 2014), Goma's Rwandan neighbor Gisenyi also experienced (cross-border) effects of voluntary migration and forced displacement linked to armed conflict. Nevertheless, the city has grown much less than Goma, a fact that can be attributed to the more stable security situation in Rwanda's recent past on the one hand, and stricter (Rwandan) state regulations, controlling population influx into cities and urban growth on the other.

The dissertation furthermore offers a counter perspective to strictly negative analyses of urban centers in the midst of armed conflict in terms of decay and calamity, such as the description of the city of Kisangani by Omasombo (2005) as a “symbol of the collapse of Congo as a whole, [...][where] traces of modernism are being obliterated [...] [and] life seems to have come to a standstill". Even if large parts of cities in Congo's warzones have been devastated and their already sparse infrastructure has been severely damaged, many of these cities grow spatially and economically despite the adverse conditions. For example, Trefon and Kabuyaya (2016) shows the inventive and dynamic responses to crisis and decline in Congo through a biographical lens. Other studies, such as (Tull, 2003) and Raeymaekers (2010), study the reconfiguration of the political order and local governance in different cities in North Kivu while addressing (urban) non-state actors, such as NGOs, churches, and rebel movements. This dissertation uses a spatial lens for analyzing the emerging forms of urbanization in a context of crisis and war, and maps their outcomes. It advances the literature by measuring, depicting, and further contextualizing urban development processes undertaken by different actors.

The methodological combination used in this dissertation demonstrated that forced displacement contributes to urban growth and densification processes, and that displaced persons settle either with host families, individually, or in camps when they lack alternatives, leading to both urban expansion and densification. Similar processes have been observed in metropolitan Freetown in Sierra Leone, which exhibited growth in the spatial extent of residential, industrial/commercial, and institutional land uses during the Sierra Leonean Civil War (1991-2002). This notable increase was attributed to the surge in population, largely fueled by forced migration (Wilson, 2014).

Another example for the elucidation of reasons for (partial) urban growth and densification was the development of Goma's military camp Katindo: not only the increased deployment

of soldiers but also the settlement of military and civilian families inside the camp led to the impressive increase in small buildings inside the camp. Densification of built-up areas within this camp was organized through unauthorized parceling and subletting mechanisms, often initiated by high-ranking military members living within or outside the camp. This process has historical precedents: for example, Nairobi's Kibera neighborhood evolved from a settlement of Nubian soldiers returning from British colonial military service at the beginning of the 20st century. Today, Kibera is one of the largest urban informal settlements on the African continent (Veljanovski et al., 2012, Hardoy and Satterthwaite, 2014). Through the provision of an exact mapping of former refugee camps, tracing their development and integration into the urban landscape(s), a mixed-method approach also made it possible to distinguish between neighborhoods that grew out of 'ordinary' city expansion versus those which were converted from makeshift camps to new neighborhoods.

Given that these processes are not limited to the study area of this dissertation, the applied approach holds significant value for elucidating patterns and drivers of planned and unplanned growth in other (urban) regions of Sub-Saharan Africa.

Methodological Contributions: Satellite Imagery Analysis and Field Research

Since the inception of satellite remote sensing, more areas of the world have been peaceful than have been recently affected by war. As such, the majority of remote sensing-based research has been conducted in peaceful environments rather than in conflict zones. War zones have also been disproportionally less studied during hot conflict phases because high levels of insecurity render fieldwork difficult. However, remote sensing-based analyses require access to the study area in order to for example, collect ground truthing information for accuracy assessment of image classifications. Furthermore, fieldwork is crucial in order to account for drivers of (urban) land-use change in conflict environments. Through the analysis of time series reaching back several decades, observations could be made in areas where access during hot conflict phases would have been too dangerous or impossible. By employing historical (satellite) data, this research shed light on past spatial developments. Furthermore, much of the compiled historical information and analyses from existing studies (e.g., on the Congo Wars, the large refugee camps in the surroundings of Goma and Gisenyi, the impact of military and international NGO/UN agency presence) had not yet been spatially analyzed and mapped. By combining this analysis with both existing and newly conducted field research underlying processes and actors could be identified. Additionally, the methodology allowed for the preselection of individual sites to study, which was

timesaving and made it possible to convey narratives from individuals or actor groups. It also allowed to gain field insights, while not physically being in the field (e.g., conducting expert interviews concerning Goma based on satellite imagery while being in Gisenyi).

The methodological combination furthermore enabled a comparison of the built cityscapes of Goma and Gisenyi. The spatial development of each city, captured with satellite imagery, served to document areal expansion and partial urban growth chronologically throughout the different Congolese and Rwandan conflict phases. Through the experiences and explanations of the various actors and informants, the analysis identified important human interactions that are not captured by the analysis of geodata or population statistics.

1.3 Outlook

During the course of writing this dissertation, a number of interesting issues have emerged that lie beyond the scope of this project. Of particular value is the further utilization of the approach applied in this dissertation to other urban areas/settlements located in conflict regions, and a more targeted and comprehensive evaluation of its suitability for geographical analyses in current and former conflict zones.

There are cities in comparable conflict and cross-border/twin-city constellations, such as Bukavu in the DRC and Cyangugu in Rwanda. Furthermore, there are comparable cities in war or post-war situations, like Bangui in the Central African Republic, Juba in South Sudan, or Gulu in Uganda, which have in common substantial growth during years or decades of conflict. In Bangui, IDPs occupied large spaces within the city, for instance, at the unofficial settlement at *M'Poko* International Airport. In Juba, UN compounds were crowded with people in search of protection, and Gulu initially grew as a result of the governmental bombardments of rural areas, and subsequently experienced a substantial post-war growth. The Congolese city of Kisangani, in contrast, experienced heavy destruction and desertion during the Congo Wars. It would be interesting to see whether urban development takes place in these cities in a manner comparable to Goma, or if the differences are so extraordinary that no general conclusions on urban development under armed conflict can be drawn.

Furthermore, two topics for future work emerge from this dissertation, which extend the applied methodological mix beyond urban topics to further conflict-related land-use change research.

One topic relates to the declining forest cover in Virunga National Park in the vicinity of Goma. Inhabitants of the densely populated Kivu region rely on charcoal, as only few alternative energy sources exist. In the park, illicit production of charcoal takes place. The production is mainly orchestrated by armed groups, in collaboration with the institutions responsible for enforcing the law to protect the park, including the Congolese army and police. How sustainable are measures like the existing paramilitary protection of the national park if there are no alternative energy sources for the local population and considering that the production of charcoal serves as a vital source of income for the largely unpaid state apparatus? Important research is being conducted on artisanal mining of coltan and other rare earth elements to financially fuel the different conflicts in Congo (Radley and Vogel, 2015, Vogel and Raeymaekers, 2016), but in the area around Goma, it is mainly illegal charcoal production, along with kidnappings, roadblocks, and other tax collection mechanisms, that provides income for members of armed groups (Bafilemba et al., 2014, Marijnen and Verweijen, 2016, Bergenas and Knight, 2015). With the help of satellite imagery analysis, deforestation hotspots could be located, and forest cover loss per annum could be quantified. Subsequent field research could then be conducted to identify the drivers and actors behind the deforestation.

Another topic for future study that has its origins in the research conducted within the framework of this dissertation relates to the presence and effects of peacekeeping missions, such as MONUSCO in Congo. MONUSCO, the largest mission in UN history, has affected Congo's land and cityscapes. As demonstrated in examples from eastern Congo, after the deployment of peacekeepers and the establishment of UN bases, IDP camps are often erected in their vicinity (Human Rights Watch, 2008, UN News/MONUSCO, 2013). Subsequently, the settlements around these bases start growing, agricultural activities resume, forests are cleared, and infrastructure construction projects are carried out. Yet, it is unclear whether these developments take place due to the peacekeepers 'fulfillment of their duty' to protect civilians (Autesserre, 2010, Whalan, 2017, Fortna, 2008).

Do people move to these locations because they feel protected by the peacekeepers, or because developmental aid and organizations come along with them? Or both? And if people do move to those locations because of the expectation of safety, are their expectations met by the real actions of the peacekeepers? Studying these questions in the dynamic context of armed conflict and resulting forced migration, combined with a traditionally mobile population in Africa's Great Lakes Region, could provide important and novel insights into the effects of peacekeeping.

Each conflict affects (urban) land use and the population living in the area in unique ways that are hard to trace over time and across dangerous zones. In hard-to-reach areas, the combination of satellite imagery analysis and field research can add valuable new insights into the complexity of the situation, and ideally help inform (local) stakeholders, such as policy makers, humanitarian actors, urban planners or a peacekeeping force.

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Eidesstattliche Erklärung

Hiermit erkläre ich, die vorliegende Dissertation selbstständig und ohne Verwendung unerlaubter Hilfe angefertigt zu haben. Die aus fremden Quellen direkt oder indirekt übernommenen Inhalte sind als solche kenntlich gemacht. Die Dissertation wird erstmalig und nur an der Humboldt-Universität zu Berlin eingereicht. Weiterhin erkläre ich, nicht bereits einen Doktortitel im Fach Geographie zu besitzen. Die dem Verfahren zu Grunde liegende Promotionsordnung ist mir bekannt.

Lisa Pech

Berlin, den 29.04.2019